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A SYMPOSIUM ON THE INSTITUTE OF PETROLEUM SAFETY CODES

AN ordinary general meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1, on Wednesday, January 10, 1951, the President, Mr C. A. P. Southwell, M.C., B.Sc., in the Chair.

The minutes of the preceding ordinary general meeting, held on December 6, 1950, were read, confirmed, and signed.

THE GENERAL SECRETARY (Mr D. A. Hough) read the list of elections to membership since the previous meeting.

THE PRESIDENT: This subject of Safety Codes is one of extreme importance to everybody concerned with the petroleum industry, not only in view of our expanding refining industry in Britain, but also to those who are connected with operations in various countries overseas, where there is always an influx of unskilled personnel. It is a service to industry of great value, and I hope that there will be a full and free discussion.

The following papers were then presented.

MODEL CODE OF SAFE PRACTICE IN THE PETROLEUM INDUSTRY

By E. J. STURGESS (Fellow)

IT is quite right and proper that every so often the chairmen of committees should be asked to give an account of their stewardship.

It was in June 1948 that the Council of the Institute of Petroleum elected the author to be chairman of the Engineering Committee, and the first task with which this Committee had to deal was the revision of the Electrical Code, first published by the Institute in 1946. The original publication was issued provisionally with a view to experience being gained, and the Engineering Committee, having received a number of helpful comments and suggestions from the users, the task of revising this Code was completed at the end of 1949. The revised Code has recently been published.

After disposing of this work, for which particular thanks are due to Mr A. D. Maclean, the Committee then started on the work of producing a Code of Safe Practice for the Petroleum Industry dealing separately with the problems met with in production, in refining, and in marketing. It was felt that there was a real need in the industry for such a Code which could be used as a guide for the industry and for authorities who were considering the framing of petroleum regulations.

Those who have had to design petroleum installations in overseas areas, and in particular marketing installations, will know the variety of ideas that exist on such items as safety distances, capacity of bunded areas, etc. Many of the regulations dealing with these points were drawn up years ago when the quality of equipment and the knowledge of operations were far below those which rule to-day. As an instance, twenty-five years ago it was the exception rather than the rule to find a gas-tight tank roof, whereas to-day welded roof construction and improvements in design enable tanks to be built to hold quite substantial pressures. One thing, however, which all regulations had in common was that all safety distances ended in a 5 or a nought, that is: 15 metres, 50 feet, 30 metres, 100 feet, etc., and the wide difference between the safety distances adopted by various authorities seems to indicate that they lacked any scientific basis and were largely the result of lack of knowledge and "playing safe."

As an example may be quoted the minimum distances between above-ground storage tanks of a given size and a boundary. For a 30,000-gallon tank the distance in East Africa has to be 20 feet and in South Africa 50 feet. In India no storage tank over 50,000 gallons may be placed within 300 feet of any boiler or furnace, whereas in Malaya such a tank need not be farther than 120 feet from any building in which fire is used.

It was felt that it would be of considerable value to the Institute if tests could be made to find out the extent of an explosive atmosphere around its source when carrying out normal operations. With the co-operation of the oil companies a very large number of tests have been carried out in temperate and tropical climates. Wherever possible such tests have been made at a time when wind velocities were as low as possible, so that the results would be likely to show the maximum distances rather than the minimum.

Results so far received have been mainly in connexion with marketing operations, and in the appendixes will be found the results of several tests which are representative of over 270. Details of all tests carried out are available in the Institute's Library.

The operations covered by these tests may be roughly divided as follows:—

(*a*) Storage tank filling.
(*b*) Vehicle, barge, and service-station tank filling.
(*c*) Drum and can filling.
(*d*) Pumping.
(*e*) Gas-freeing of storage tanks.
(*f*) Handling of liquefied petroleum gases.
(*g*) Miscellaneous.

The fullest data concerning conditions existing during the test has not always been supplied. For example, the dimensions and ventilation conditions in buildings are not always available, but the following general inferences may be drawn from the results submitted:—

(a) *Storage Tank Filling*

Pumping rate, wind velocity, and possibly the size of the opening through which vapour is escaping would be expected to influence the spread of gasoline vapour. Insufficient results are available to enable a relationship

to be established between pumping rate and spread of vapour at a given wind velocity, or alternatively to establish for a given pumping rate the effect of wind velocity on the spread.

With wind blowing, even very light wind, the maximum distance in a horizontal direction to which an explosive mixture reached was 12 feet, and in a vertical direction 3 feet (this was with a pumping rate of 180 tons per hour and a fresh wind, *i.e.*, 17 to 21 m.p.h.). However, if there is absolutely no wind the distances may be greater. In one case in which vapour was escaping through the p.v. valves, the gas-recovery system being overloaded, an explosive mixture was found up to 35 feet in a horizontal direction and up to 6 feet above a valve (pumping rate about 300 tons per hour).

(b) *Vehicle, Barge, and Service-station Tank Filling*

In general, with wind blowing, if the opening through which vapour is escaping is of small diameter, *e.g.*, a 1½-inch dip hole, explosive mixtures may be found up to about 7 feet above it, but they do not spread laterally to more than about 3 feet. On the other hand, if the vapour is escaping through a manhole the vertical spread is less, but the horizontal may be greater—up to 8 feet. In still air conditions, an explosive mixture was found to extend above a manhole up to 7 feet.

As in the case of storage tanks, insufficient data is available to correlate rate of filling with spread of vapour under constant wind conditions, or for a given filling rate to correlate wind velocity with spread of vapour.

(c) *Drum and Can Filling*

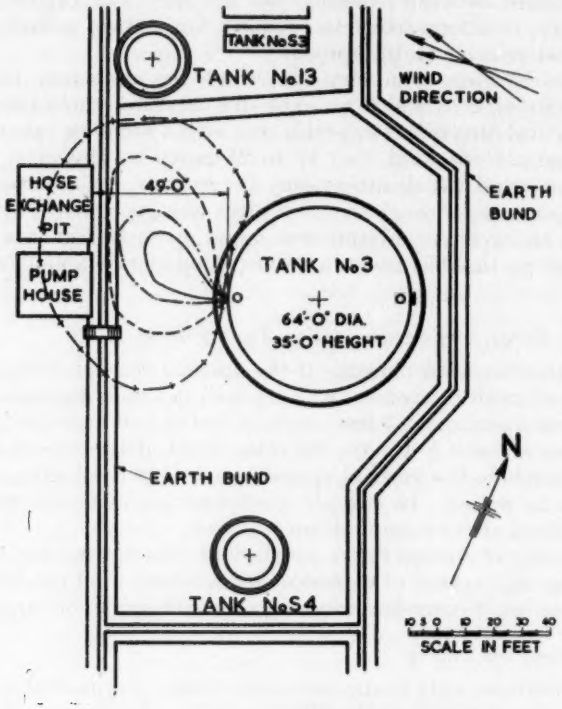
In still conditions, only in one case (drum filling) was an explosive mixture found more than 1 foot from the filling opening. In this case the explosive mixture persisted to 3 feet above the opening (filling rate 1000 to 1250 gallons per hour).

(d) *Pumping.*

In no case, even when glands were leaking, was an explosive mixture found more than 1 foot from the source. With a priming funnel of a centrifugal pump half-full of gasoline, an explosive mixture was found only up to 1 foot above the surface.

(e) *Gas-freeing of Storage Tanks*

It is clear that when there is little movement of air a dangerous atmosphere may extend for a considerable distance around a tank which is being gas-freed. Several cases were reported where this spread was between 70 and 80 feet. It is of interest to note from Figs. 1 and 2 that the extent of the dangerous area can be controlled very simply by the extent to which the bottom manhole is opened, and in cases where gas-freeing has to be carried out in still-weather conditions some such precaution would be desirable if boiler-houses have to be operated at distances up to, say, 120 feet from the tank. The gas-freeing of tanks is not an everyday operation, but is one in which special precautions need to be taken by the operatives in charge, and it would not be reasonable to legislate for safety distances to cover special operations which take place only at long intervals.



	TIME	BOTTOM MANHOLE	RELATIVE HUMIDITY	TEMP. OUTSIDE TANK
——→	08·00	FULL OPEN	91%	78° F
— — →	08·15	¾ "	88%	79° F
— · — →	08·30	½ "	86%	80° F
——→	08·45	¼ "	83%	81° F

FIG. 1

THE ABOVE LINES INDICATE WHERE GAS CONCENTRATION IS ABOVE 100% OF LOWER EXPLOSIVE LIMIT

Wind: light, slightly variable, velocity 1–4 m.p.h.

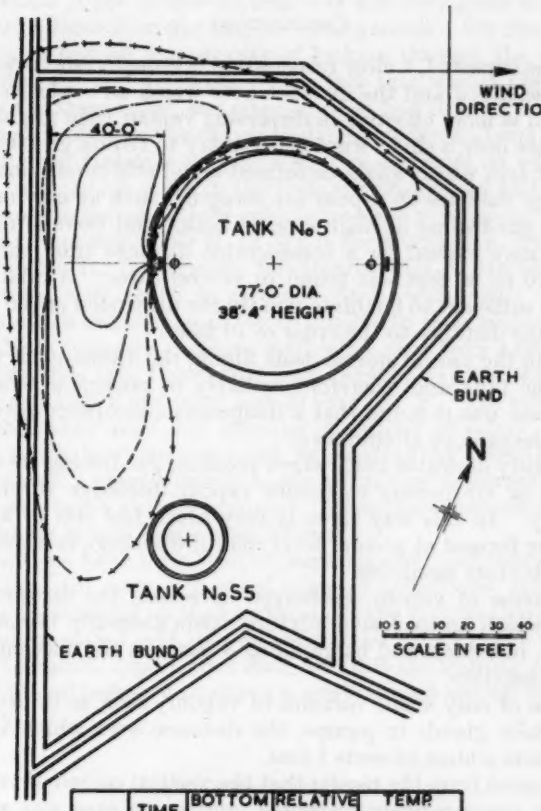
EXTENT OF DANGEROUS ATMOSPHERES DURING GAS-FREEING OF MAIN MOTOR GASOLINE STORAGE TANK AT SHIMANZI

(f) *Handling of Liquefied Petroleum Gases*

In no case was a dangerous atmosphere found more than a foot or two from the source of gas.

(g) *Miscellaneous*

Several miscellaneous conditions have been tested, such as hose-exchange pits, tank-wagon filling points when not actually filling, lighter discharge decanting of drums, drum cleaning, drum steaming, a leaky valve at the base of a gasoline storage tank, etc. In none of these cases was an explosive mixture found more than a foot or two from the source. In one instance



	TIME	BOTTOM MANHOLE		RELATIVE HUMIDITY	TEMP. OUTSIDE TANK
→→	07·45	FULL	OPEN	89%	79°F
- - -	08·00	¾	-	88%	79°F
——	08·15	½	-	85%	80°F
——	08·30	¼	-	83%	81°F

FIG. 2

THE ABOVE LINES INDICATE AREA WHERE GAS CONCENTRATION IS ABOVE 100% OF LOWER EXPLOSIVE LIMIT

Wind : light, variable, velocity 1–3 m.p.h.

EXTENT OF DANGEROUS ATMOSPHERES DURING GAS-FREEING OF MAIN MOTOR GASOLINE STORAGE TANK AT SHIMANZI

an explosive mixture was found 3 feet away from a leaky bung in a stack of drums, and in another 12 feet away from an open test cock in a pipe trench. In the latter case it was suggested that the gasoline had been carried on the surface of pools of water. A test at a refinery was also carried out near a flange on a 3-inch line containing light petroleum distillate and C_4 hydrocarbons, which had been broken out in order to release pressure while a unit was being shut down for repairs. There was very little wind, and an explosive mixture was detected up to a distance of between 50 and 70 feet from the source.

Conclusions

As would be expected, a clear relationship is brought out between volume of vapour discharged and the distance over which an explosive mixture is found. Wind is more effective in dispersing vapour than might have been imagined, since only a slight wind is necessary to reduce greatly the extent of the danger area which would be formed under still conditions.

Where large volumes of vapour are escaping, such as may occur during the filling or gas-freeing of main storage tanks, and there is no wind, the danger area may extend for a considerable distance from the source; a distance of 70 to 80 feet was found in several cases. A relatively slight wind may be sufficient to facilitate greatly the dispersion of the vapour and may reduce the distance to the order of 10 feet.

However, in the case of storage-tank filling, the discharge of vapour is at the top of the tank and, therefore, unlikely to present a serious hazard, since in no case was it found that a dangerous atmosphere persisted down the sides of the tank to ground level.

It is obviously desirable that, where possible, gas-freeing should be done by steaming or air-moving to ensure vapour discharge through the top manhole only. In this way there is very much less risk of an explosive mixture being formed at ground level than if discharge is wholly or partly through the bottom manholes.

As the volume of vapour discharged decreases, the distance from the source over which an explosive mixture exists naturally becomes smaller. For example, in vehicle and barge filling 8 feet was the maximum distance under still conditions.

In the case of only small volumes of vapour, such as in drum and can filling and leaky glands in pumps, the distance over which an explosive mixture persists seldom exceeds 1 foot.

It will be noted from the results that the vertical spread of vapour above the source is comparatively restricted, and in no case was an explosive mixture found more than 8 feet above a source. This suggests that in defining the extent of a dangerous area caused by a gas heavier than air a smaller distance may be specified for the vertical direction than for the horizontal, thus in practice perhaps reducing considerably the number of cases where flameproof light fittings, etc., are required.

From remarks made in connexion with some of the tests it is clear that a strong smell of gasoline is interpreted as indicating a dangerous concentration of gas, but this is not necessarily true.

The majority of these tests have been carried out using the "Poole" explosimeter. All instruments were carefully checked before and during use, and all tests have been carried out by qualified chemists well acquainted with the technique necessary to ensure accurate results.

It should be made clear that the distances referred to above are those up to which a gas concentration of 100 per cent or more of the lower explosive limit extended. Gas in lower concentration than this was detected over appreciably greater distances.

The results found in these tests will be of considerable interest to the petroleum industry. It may be said that spot tests carried out in the manner described can be misleading, and the fact that when the test was

made the extent of the dangerous area was not very great does not mean that 5 minutes later it might not be even greater. On the other hand, those who have had an opportunity of looking through the complete list of tests carried out will be struck by the fact that results obtained everywhere are of the same order, and when one has had to work for many years without any indication of the extent of dangerous areas, tests such as have been made for the Institute do give some definite basis on which to work.

With the information given in the tests at our disposal and with further tests still being carried out, three sub-committees were set up in May 1949 under the chairmenship of Mr H. de Wilde for Production, Dr F. Mayo for Refining, and Mr R. L. Sarjeant for Distribution & Marketing. These Sub-Committees were asked to consider, draft, and report on minimum safety codes which might reasonably be applied to their respective sections of the petroleum industry. Where applicable, they were asked to classify petroleum products into those with flash points: (1) less than 73° F, (2) between 73° and 150° F inclusive, and (3) over 150° F. The sub-committees were told that they need not consider questions of safety in design of equipment, which is already covered by existing API/ASME Codes, but should cover safety precautions to apply when new construction is undertaken on a site or area already occupied. They were also asked to consider practice overseas as well as in Great Britain.

The committees have now been at work for over eighteen months and, having got over the very important stage of definitions, are now at the stage of actually drawing up their codes under the various chapter headings.

In conclusion, may I add that no amount of safety codes will take the place of well-trained, experienced staff, and it is the training of staff which has enabled the oil industry to retain a safety record second to none in the world to-day.

Acknowledgments

The author would like to thank his colleagues on the Engineering Committee, and especially those on the particular sub-committees which have been doing the work, for the time they have given to the vast task of preparing these Codes.

APPENDIX A
RESULTS OF GASOLINE VAPOUR CONCENTRATION TESTS

Clyde, Sydney, Australia
Date : 10.30 a.m., December 2, 1949.
Temperature : 71° F (dry bulb 68° F).
Wind : 0 ft/sec.
Humidity : 87%.
Source of vapour : Filling 44-gal drums. Gas-return hose disconnected. Opening, 2¼ inches dia; rate of discharge, 1800 gal/hr.
Temperature of source : 60° F.
Gasoline : Motor spirit; vapour pressure 5–6 p.s.i. at 63° F.

Distance from source, ft	Readings, % lower explosive limit					
	Vertical		Horizontal			
	Above	Below	N	S	E	W
1	0	100	100	5	5	10
2	—	60	50	0	0	5
3	—	60	30	—	—	0
4	—	—	30	—	—	—
5	—	—	30	—	—	—
6	—	—	15	—	—	—
7	—	—	0	—	—	—

With the gas-return hose in place and a washer used with the nozzle no gas could be detected.

East Africa
Date : July 17, 1949.
Temperature : 85° F.
Wind : S, Force 5.
Humidity : 60%.
Source of vapour : Open dipping hatch, 2 ft dia, of unlagged conical fixed roof tank during filling at 180 tons/hr by bottom-filling method.
Temperature of source : 87° F.
Gasoline : Motor spirit; vapour pressure 7·5 p.s.i. at 100° F.

Distance from source, ft	Readings, % lower explosive limit					
	Vertical		Horizontal			
	Above	Below	N	S	E	W
1	100	100	100	Nil	100	Nil
2	100	Nil	100	—	100	—
3	100	—	100	—	100	—
4	80	—	100	—	100	—
5	50	—	100	—	100	—
6	Nil	—	100	—	100	—
7	—	—	100	—	100	—
8	—	—	100	—	80	—
9	—	—	100	—	80	—
10	—	—	100	—	90	—
12	—	—	100	—	80	—
14	—	—	60	—	50	—
16	—	—	60	—	30	—
18	—	—	20	—	15	—
20	—	—	15	—	Nil	—
25	—	—	20	—	—	—
30	—	—	Nil	—	—	—

Alexandria, Egypt

Date : 10 a.m., June 8, 1949.
Temperature : 70° F.
Wind : Negligible.
Humidity : 70%.
Source of vapour : Leaking gland dripping on to shaft housing of centrifugal pump, while pumping motor spirit at 40 cu.m/hr.
Temperature of source : 75° F.
Gasoline : 69 O.N. leaded motor spirit; vapour pressure, 7·2 p.s.i.

Distance, from source, inches	Readings, % lower explosive limit					
	Vertical		Horizontal			
	Above	Below	N	S	E	W
1	100	0	—	—	—	—
6	0	—	—	—	—	—

Note : Motor-room separated from pump-room by wall, with shaft passing through a gland in wall.

Readings in all parts of room nil.

Sewree, Bombay

Date : November 30, 1949.
Temperature : 90° F.
Wind : SE–NW, 6 ft/sec.
Humidity : 45%.
Source of vapour : Tank-wagon filling.
Gasoline : 100 O.N. aviation spirit; vapour pressure, 5·9 p.s.i. at 100° F.

Distance from source, ft	Readings, % lower explosive limit					
	Vertical		Horizontal			
	Above	Below	N	S	E	W
½	100	100	100	100	100	100
1	100	Less than	100	100	100	100
1½	100	five	100	100	80	100
2	100	—	100	80	60	60
2½	100	—	100	65	25	45
3	60	—	80	40	Less than	25
4	30	—	80	20	five	15
5	25	—	60	Less than	—	Less than
6	25	—	15	five	—	five
7	20	—	Less than	—	—	—
8	15	—	five	—	—	—
9	10	—	—	—	—	—
10	10	—	—	—	—	—
12	5	—	—	—	—	—
14	Less than five	—	—	—	—	—

Remarks : The gasoline was being pumped into tank wagons at an approximate rate of 100 tons/hr. The filling was done from the bottom, and the vapour-return arrangement was intact. The diameter of the dip hole was about 1½ inches.

Readings could be taken up to about 12 ft vertically above the manhole. By means of a special arrangement for raising the tube the experiment was completed. Gas could be detected up to about 12 ft vertically above the dip hole.

There was a slight breeze from SE to NW. Gas could be detected up to about 7 ft in the windward direction and 5 ft in other directions horizontally from the dip hole.

APPENDIX B

EXTENT OF DANGER AREA AROUND EXPOSED GASOLINE VAPOUR *

By J. D. Black, D. C. Charlton, and W. R. Prentice

Introduction

The Institute of Petroleum are in course of compiling an electrical code covering electrical equipment used in the petroleum industry. It is proposed to include the following clause :—

"*In the open air and in relation to apparatus other than overhead line conductors, the dangerous area is not considered to extend beyond any point which is distant at least* 25 *ft in horizontal projection from and* 15 *ft in vertical projection above any point of emission of heavier than air dangerous atmosphere.*"

The Institute of Petroleum also wish to have more precise information on the minimum safe height of a wall between an electric motor on the one side and explosive mixtures on the other.

We have been asked to conduct an investigation on the extent of spread of gasoline vapours under various conditions, with particular reference to the above two points.

Summary

Experiments have been carried out in an endeavour to define the limits of spread of gasoline vapours during various loading operations and during controlled conditions of temperature and wind velocity.

It was found that under atmospheric temperatures of 45°–90° F and wind velocities up to 7 ft/sec a point situated 25 ft horizontally and 15 ft vertically from a source of gasoline vapour is safe for the use of non-flameproof electrical equipment. It was also found that a wall 15 ft high is adequate safeguard from gasoline vapours liberated at the base of the wall.

Experimental

The work can be divided into three groups, based on the conditions under which measurements were made.

(1) *Operational experiments.* Measurements taken during installation operations, such as loadings, etc.

(2) *Tunnel experiments.* Measurement of spread of gasoline vapours under controlled conditions of temperature and wind velocity.

(3) *Wall experiments.* Measurement of spread of gasoline vapours over walls of various heights.

In all sets of experiments the following conditions were measured :—

Wind velocity—in feet per second, using an anemometer.

Humidity—using a whirling psychrometer.

Atmospheric temperature.

Gas concentration—using the M.S.A. gas detector, which was rigorously checked two and three times per day throughout the length of the experiments. It was found to be correct at all checks. All readings expressed are direct readings on the M.S.A. instrument, *i.e.*, percentage of the "lower explosive limit."

1. *Operational Experiments*

(a) *Rail-car Loading*

The gasoline used was Pool motor spirit being pumped into rail cars at approx 100 tons/hr. The atmospheric temperature was 50° F, and humidity 67, with a wind velocity of 6 ft/sec. The surface area of the manhole was 1·8 sq. ft. Gas was detected on the leeward side of the manhole up to 6 ft away, when a zero reading was obtained; a vertical height of 2 ft above the manhole gave zero readings.

(b) *Road-car Loading*

The gasoline loaded was Pool motor spirit pumped at a rate of approx 50 tons/hr. The atmospheric temperature was 55° F, and humidity 94 with a wind velocity of 3·1 ft/sec. The surface area of the dip holes was 24·5 sq. in. Gas was detectable on the leeward side up to 5 ft, beyond which a zero reading was obtained; a vertical height of 4 ft above the dip hole gave zero readings.

* Dated November 19, 1948.

(c) *Barge Loading*

The gasoline loaded was Pool motor spirit pumped at a rate of approx 250 tons/hr. The atmospheric temperature was 55° F, and humidity 82, with a wind velocity of 7·1 ft/sec. The surface area of the manhole was 3·1 sq. ft. Gas was detectable on the leeward side up to 20 ft and up to a vertical height of 4 ft above the manhole, beyond which zero readings were obtained. A similar experiment was carried out under the same climatic conditions on a barge being loaded with distillation benzine No. 1 at 100 ton/hr. Gas was detected on the leeward side up to 12 ft and up to a vertical height of 3 ft above the manhole, beyond which zero readings were obtained.

Unfortunately we have not been able to conduct experiments during tank cleaning, hose breaking in exchanges, or during the receiving of gasoline into a storage tank when the pressure/vacuum relief valve was blowing, since these opportunities did not arise during the period of experiments.

The results obtained in the above experiments are well within the limitations proposed, although it is realized that no high winds were encountered.

2. Tunnel Experiments

In an endeavour to obtain some fundamental information on the effect of temperature and wind velocity on the spread of gasoline vapour, use was made of the paraffin wax sweating tunnel, where close control of air speed and temperature could be maintained.

The source of vapour was casinghead gasoline contained in a metal tray with a surface area of 4 sq. ft. This tray was placed 2 ft from the ground in the centre of the tunnel at a point approximately 45 ft from the end, at which point wind conditions were uniform across the tunnel.

Concentrations of vapours were measured at 45° F, 70° F, and 90° F with wind velocities of nil, 2·5 ft/sec, and 5 ft/sec. Unfortunately the wind velocity could not be increased above 5 ft/sec. In all cases measurements were taken at various distances

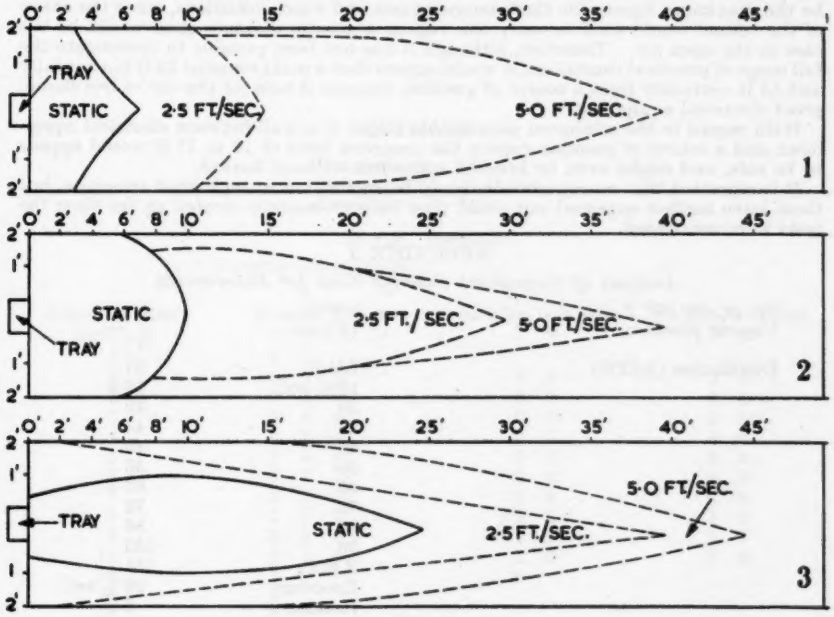


FIG. 3

TUNNEL EXPERIMENTS ON SPREAD OF GASOLINE VAPOURS

Casing head gasoline. Surface area of tray, 4 sq. ft.

	1	2	3
Temperature, ° F . . .	45	70	90
Humidity	85	75	80

and elevations until zero readings were obtained. These observations are tabulated in Appendix II. For ease of observation, however, the zero readings for maximum distance regardless of height have been plotted graphically, and are given in Fig. 3.

The greatest distance at which vapours were detected was 40 ft down wind. In the vertical plane the maximum height at which vapour was detected was 3 ft above the level of the tray, at a distance of 9 ft downward from it.

3. *Wall Experiments*

A tarpaulin sheet was rigged up in an alleyway between two buildings in such a manner that it could be raised and lowered at will. Casinghead gasoline was poured into a tray set on the ground with a surface area of 4 sq. ft. and set on the windward side and at a distance of 5 ft away from the sheet. The atmospheric temperature was 53° F, humidity 94, and the wind velocity was 2·5 ft/sec (light air).

Gas was detected on the tray side of the wall up to 4 ft high, but no gas was detected on the other side of the wall until the wall height was lowered to 2 ft above ground level. It must be pointed out that the atmospheric temperature was well below that encountered during summer months, and hence heights greater than 2 ft will be required during warmer weather.

Conclusions

In road- and rail-car loadings no gas could be detected with the N.S.A. gas detector outside an area extended 6 ft horizontally and 4 ft vertically to the leeward of the dip or manhole. In barge loading the gas area extended 20 ft horizontally and 4 ft vertically to the leeward of the open manhole. These tests were made with an air temperature of 50°–55° F and wind velocities ranging from 3 to 7 ft sec.

Tunnel experiments have shown that increase of temperature and of wind velocity cause increase in the horizontal spread of the gas vapours but have little effect on vertical spread. The effect of increased wind velocity, however, decreases as the temperature rises. The results obtained on the extent of horizontal spread should be the maximum figures for these temperatures and wind conditions, since the shape of the tunnel would tend to carry the vapour a greater distance than would be the case in the open air. Therefore, although it has not been possible to investigate the full range of practical conditions, it would appear that a point situated 25 ft horizontally and 15 ft vertically from a source of gasoline vapours is safe for the use of non-flame-proof electrical equipment.

With regard to the minimum permissable height of a wall between electrical equipment and a source of gasoline vapour the proposed limit of 10 to 15 ft would appear to be safe, and might even be lowered somewhat without hazard.

It is regretted that no experiments could be carried out at high wind velocities, but these have neither appeared nor could they be conveniently created at the time the tests were conducted.

APPENDIX I

Analysis of Casinghead Gasoline Used for Experiments

Sp. gr. 60°/60° F	0·6625	—
Vapour pressure	16 p.s.i.	—
		°C.
Distillation (ASTM)	I.B.P.	27
	10% vol.	35·5
	20	40
	30	44
	40	49
	50	55
	60	62·5
	70	72
	80	86
	90	103
	F.B.P.	151
	Recovery	98% vol.
	Residue	1·0
	Loss	1·0
	Recovered to:	
	70° C	68% vol.
	100° C	88 vol.
	140° C	96·5 vol.
	Barometer	773 mm.
	Temperature	23° C

APPENDIX II

In all of the following tables, heights are measured from ground level. It should be noted that the tray is situated 2 ft. above ground level.

TABLE I

Temperature : 45° F
Air velocity : Nil
Humidity : 85

M.S.A. Readings

1 ft Directly above liquid	2
2 „ „ „	2
3 „ „ „	1
4 „ „ „	0

Distance from liquid, ft	Height, centre						Height, 1 ft side					Height, 2 ft side		
	0	1	2	3	4	5	0	2	3	4	5	2	3	4
0	10	4												
1	9	4	2	2	1	0	4	3	2	1	0	1	1	0
2	9	3	2	2	1		3	3	1	0		1	0	
3	7	4	0	0	0		2	0	0			0		
4	3	1					0							
5	2	1												
6	1	0												
7	0													

TABLE II

Temperature : 45° F
Air velocity : 2½ ft/sec
Humidity : 85

M.S.A. Readings

1 ft Directly above liquid	0
2 „ „ „	0

Distance from liquid, ft	Height, centre				Height, 1 ft side		Height, 2 ft side	
	0	1	2	3	2	3	2	3
0	0	0						
1	0	0	9	0	0	0	0	0
2	0	2	5		0	0	0	0
3	0	4	4		0	0	0	0
4	1	4	4		0	0	0	0
5	2	3	4		0	0	0	0
6	2	2	2		0	0	0	0
7	2	2	1		1	0	0	0
8	2	2	1		1	0	1	0
9	2	2	1		1	0	1	0
10	2	1	0		1	0	0	0
12	2	0			0			
14	1							
15	0							

TABLE III

Temperature : 45° F
Air velocity : 5 ft/sec
Humidity : 85

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, ft	Height, centre				Height, 1 ft side		Height, 2 ft side	
	0	1	2	3	0	2		2
0	0	0						
1	0	0	4	0		0		0
2	0	0	2	0		0		0
3	0	0	2	0		0		0
4	0	0	2	0	0	0		0
5	0	0	2	0	0	0		0
6	0	2	2	0	0	0		0
7	1	2	2	0	1	0		0
8	1	2	2	0	1	0		0
9	2	2	2	0	1	0		0
10	2	2	2	0	2	0		0
12	2	2	1	0	2	0		0
14	2	2	1	0	1	0		0
15	2	2	1	0	1	0		0
20	2	1	0	0	1	0		0
25	2	1			1	0		0
30	2	0			0			
34	1							
40	0							

TABLE IV

Temperature : 70° F
Air velocity : Nil
Humidity : 75

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, ft	Height, centre				Height, 1 ft side			Height, 2 ft side	
	0	1	2	3	0	2	3	2	3
0	0	0							
1	0	0	0	2	0	0	0	0	0
2	0	1	1	1	2	2	0	1	0
3	1	2	1	0	2	2	0	2	0
4	1	1	1	0	2	2	0	2	0
5	2	1	0	0	2	1	0	1	0
6	2	2	0	0	1	0		0	
7	2	2	0	0	1	0		0	
8	2	1	0	0	1	0			
9	2	0	0	0	0	0			
10	0				0	0			
12	0								

TABLE V

Temperature : 70° F
Air velocity : 2½ ft/sec
Humidity : 75

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, ft	Height, centre					Height, 1 ft side				Height, 2 ft side
	0	1	2	3	4	0	2	3	4	2
0	0	0								
1	0	0	6	2	0	0	0	0	0	0
2	0	0	6	1	0	0	0	0	0	0
3	2	3	4	2	0	0	0	0		0
4	3	3	3	2	0	0	0	1	0	0
5	3	3	2	1	0	1	0	1	0	0
6	4	3	1	0		2	1	1	0	0
7	4	3	1	0		2	2	1	0	0
8	3	3	1	0		2	2	0		0
9	3	2	0			2	1	0		0
10	3	1	0			2	1			0
12	3	2	0			2	0			0
14	3	2	0			1	0			0
15	2	2	0			1	0			0
20	2	0	0			0				0
25	1	0								
30	0									

TABLE VI

Temperature : 70° F
Air velocity : 5 ft/sec
Humidity : 75

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, in ft	Height, centre					Height, 1 ft side		Height, 2 ft side
	0	1	2	3	4	0	2	2
0	0	0						
1	3	0	12	0	0	0	0	0
2	0	3	11	0	0	0	0	0
3	0	4	10	0	0	0	0	0
4	0	4	10	0	0	0	0	0
5	0	4	9	0	0	0	0	0
6	1	4	7	1	0	1	0	0
7	2	4	6	1	0	1	0	0
8	2	4	6	0	0	2	0	0
9	3	4	5	0		2	0	0
10	3	4	4	0		2	0	0
12	3	3	2	0		2	0	0
14	3	2	2	0		2	0	0
15	3	2	0	0		2	0	0
20	2	1				0	0	0
25	1	0						
30	1							
40	0							

TABLE VII

Temperature : 90° F
Air velocity : Nil
Humidity : 80

M.S.A. Readings

1 ft Directly above liquid 2
2 „ „ „ 0

Distance from liquid, ft	Height, centre				Height, 1 ft side		Height, 2 ft side
	0	1	2	3	0	2	2
0	0	0					
1	0	2	2	2	0	0	0
2	2	2	2	1	0	0	0
3	2	2	2	1	0	0	0
4	2	2	2	0	0	0	0
5	2	2	2	0	1	0	0
6	2	2	2	0	1	0	0
7	2	2	2	0	1	0	0
8	2	2	1	0	1	0	0
9	2	2	1		1	0	0
10	2	2	0		1	0	0
12	2	2	1		0	0	0
14	1	1	1				
15	1	1	0				
20	1	0	0				
25	0						

TABLE VIII

Temperature : 90° F
Air velocity : 2½ ft/sec
Humidity : 80

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, ft	Height, centre						Height, 1 ft side				Height, 2 ft side	
	0	1	2	3	4	5	0	2	3	4	1	0
0	3	2										
1	2	4	5				2	0	0		1	0
2	2	9	6				2	0	0		0	0
3	6	8	4				3	2	0			0
4	7	7	2				3	2	0			0
5	4	2	1				3	2	0			0
6	4	2	2				3	2	0			0
7	3	2	2				3	2	0			0
8	3	2	2	0	0		3	2	0			0
9	2	4	2	0	0		2	0	0			
10	1	3	4	0	0		1	0	0			
12	1	2	3	2	1	0	0	0	0			
14	2	3	3	1	2	0	1	1	0			
15	2	2	4	1	1	0	0	0	0			
20	1	2	2	1	0	0	0	0				
25	0	1	1	0	0							
30	0	0	1	0	0							
34			1									
40			0									

TABLE IX

Temperature : 90° F
Air velocity : 5 ft/sec
Humidity : 80

M.S.A. Readings

1 ft Directly above liquid 0
2 „ „ „ 0

Distance from liquid, ft	Height, centre						Height, 1 ft side					Height, 2 ft side			
	0	1	2	3	4	5	0	2	3	4	5	2	3	4	5
0	0	0	0	0	0										
1	0	2	8	4	1		0	0							
2	0	2	9	4	3		0	0							
3	0	3	8	5	2		0	0							
4	0	3	8	6	2		0	1	0						
5	0	4	6	6	2		1	1	0			0	0		
6	0	4	6	4	2		1	1	1	0		1	1	0	0
7	2	4	6	4	2		1	1	1	0		0	1	0	0
8	2	4	5	4	1	0	2	1	2	0		0	1	0	0
9	3	4	5	4	3	1	2	1	1	0		0	1	1	0
10	4	4	4	6	4	2	2	1	1	2	1	0	1	1	0
12	2	4	4	4	4	2	2	1	1	2	1	0	1	1	0
14	2	4	2	4	3	1	2	1	1	1	0	0	1	0	0
15	2	3	2	2	2	0	1	1	1	0	0	0	0	0	
20	2	2	2	2	0		1	0	0	0			0		
25	0	1	1	2	0		1								
30	1	1	1	1			0								
34	2	0	0	0											
45	0														

APPENDIX C

EXTENT OF DANGER AREA AROUND EXPOSED GASOLINE VAPOUR

INTRODUCTION

Following upon the previous report (Appendix B) further experiments have been carried out on the flow of gasoline vapours down an inclined plane.

SUMMARY

The experiments now reported upon have been carried out with a view to comparing the flow of explosive vapours down an inclined as opposed to a horizontal plane. Under the prevailing atmospheric temperature it was noted that vapours could be detected up to a distance of 20 ft from the source (this distance being approximately half that recorded when testing on a horizontal plane).

Vapours were observed to fan out more widely on an inclined plane than on a horizontal plane, although concentrations were no higher (cf. Table II).

EXPERIMENTAL

For the purpose of this experiment, use was again made of the paraffin wax sweating tunnel. The inclined plane was built of tubular scaffolding, making a structure with a vertical height of 6 ft and a horizontal length of 30 ft. The framework was covered with a tarpaulin to give a smooth surface, and a tray of 4-sq. ft. area was placed at the top of the slope. The tray was filled with casinghead gasoline, and conditions were assessed as described in the original report.

RESULTS

The concentration of the vapour was measured at varying distances from the source and at elevations up to 3 ft from the surface until zero readings were obtained. These observations were made at atmospheric temperature with wind velocities of nil, 2·5 ft/sec, and 5 ft/sec. Fig. 4 shows the range beyond which no gas could be detected by M.S.A. meter. Detailed readings are appended. It should be noted that there is no appreciable spillage of vapour over the side of the plane.

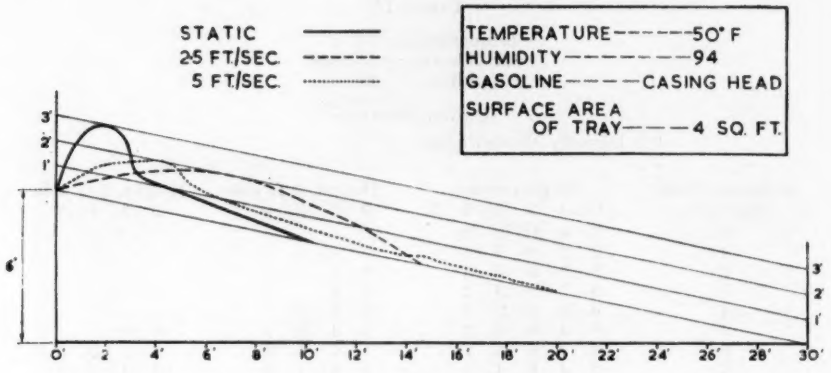


FIG. 4

SPREAD OF GASOLINE VAPOURS

TABLE I

Temperature : 50° F
Air velocity : Nil
Humidity : 94

M.S.A. Readings

Distance from liquid, ft	Height, centre				Height, 1 ft side				Height, 2 ft side			
	0	1	2	3	0	1	2	3	0	1	2	3
0												
1	0	0	2	3	0	2	4	2	0	1	1	1
2	3	1	1	0	3	1	1	0	2	0	0	0
3	5	0	0	0	5	0	0	0	2			
4	5	0			5				2			
5	4				2				2			
6	4				2				2			
7	2				2				1			
8	2				2				1			
9	1				1				1			
10	0				0				0			

TABLE II

Temperature : 50° F
Air velocity : 2½ ft/sec
Humidity : 94

M.S.A. Readings

Distance from liquid, ft	Height, centre				Height, 1 ft side				Height, 2 ft side			
	0	1	2	3	0	1	2	3	0	1	2	3
1	5	7	2	0	0	0	0	0	0	0	0	0
2	5	3	2	0	0	0	0	0	0	0	0	0
3	4	3	2	0	0	2	0	0	0	0	0	0
4	3	2	1		0	2	0		0	0	0	
5	3	2	1		1	2	0		0	0		
6	3	1	1		1	1			0			
7	3	1	1		1	1			0			
8	2	1	0		1	1			1			
9	2	1			1	1			1			
10	2	1			1	0			1			
12	1	0			1				1			
14	1				0				0			
15	0											

TABLE III

Temperature : 50° F
Air velocity : 5 ft/sec
Humidity : 94

M.S.A. Readings

Distance from liquid, ft	Height, centre				Height, 1 ft side				Height, 2 ft side			
	0	1	2	3	0	1	2	3	0	1	2	3
1	0	9	4	0	0	0	0	0	0	0	0	0
2	2	7	2	0	0	2	1	0	0	0	0	0
3	2	4	2	0	0	2	1	0	0	0	0	0
4	4	2	1		2	1	0		0			
5	4	1	0		2	1			0			
6	4	0			2	0			1			
7	4				2				1			
8	3				2				1			
9	3				2				1			
10	2				2				1			
12	1				1				0			
14	1				0							
15	1											
20	0											

I.P. SAFETY CODES
APPLICATION TO DRILLING AND PRODUCTION

By H. DE WILDE (Fellow)

IN order to understand better the motives which are impelling us to the laudable labours involved in setting up a safety code it may help if we cast a brief glance in the past. Mining has been practised for centuries. Neolithic man used the flints of the upper chalk to fashion weapons and perhaps some more useful articles. There are examples of his underground workings in the southeast of England. It is held probable that about 3000 B.C. the Egyptians opened up the copper mines in the Peninsula of Sinai, while the vast quarries of Turra, near Cairo, give proof that at a very early date open working was abandoned in favour of shafts. Wells, of which Joseph's Well in Cairo is an example, were sunk down to depths of 300 feet about 2500 B.C. The copper mines of Rio Tinto and Tharsis in Spain were worked by the Romans and the Carthaginians, and the method of working was extremely simple; the slaves in the mines had to scratch off with their fingers the clay which covered the ore. The clay which is found nowadays in these ancient mines still bears the impress of thousands of fingers. The term " scratching for a living " very probably originated from the labours of these poor souls.

All these workings were possible because slave labour was plentiful, life was cheap and sacrificed with reckless disregard. Man's inhumanity to man knew no bounds, knows no bounds, and probably will never know any bounds. However, when economics enters into the matter, then measures are taken to protect the worker from possible harm, because injury or death may have an adverse affect on operations.

The birth of the oil industry, was heralded with Drake's well in Virginia in 1859, a very primitive start for a great industry. It is difficult to ascertain how this well was made. Contemporary pictures show a wigwam-like structure with two or three brawny bewhiskered gentlemen outside,

but no machinery. Since the well was only 65½ feet deep, it was well within the capacity of a hand auger.

As the oil industry developed and wells grew deeper the drilling rigs changed from man-actuated spring poles to engine-driven percussion rigs. About 1899 the first rotary made its appearance, but it was not until 1914 that it found any appreciable application. It was a poorly engineered job. The tooljoint had already made its appearance, considerably speeding up the pulling operation. The kelly or grief stem had not been thought of, and the drill pipe was extended to the swivel, thus giving right-hand threads above the table. In turning to the right these joints above the table tended to unscrew, and if they did serious accidents were liable to occur, especially when reaming. The hook was not provided with a safety latch. The old derricks had no crown platform with rail, and derrick men's safety belts were unknown. The crown block was made up of wooden beams hollowed out and babbitted to take the journals of the cast-iron crown sheaves, while the draw-works was an unhappy combination of cast iron, wood, ordinary commercial bolts, and mild-steel shafting. The depth limit of the rotary drilling rigs in 1914 was about 3000 feet. Certain crude protection was offered to the driller and crew by boarding in the drum chain drives, particularly the low-speed adjacent the driller. The rotary-table chain drive extended from the draw-works halfway across the derrick floor, and in the absence of suitable cotters, nails were frequently used for repair, converting the chain into a device similar to a coal-cutter which buzzed across the derrick floor ready to cut to shreds anybody coming in contact with it.

Gradually wooden beams were replaced by structural steel and the hoist was unitized. The wooden derrick was replaced by the structural-steel derrick. Originally this was not an improvement, since the wooden derrick gave ample warning, when pulled on, of impending collapse—the steel derrick gave no such warning. The weight indicator, however, became a necessary adjunct to ensure that the pull did not exceed the safe load capacity of the derrick. Unfortunately the weight indicator registered the correct load only if the circuit was *completely* filled with liquid. An entrapped bubble of air would give false low readings and has led to accidents. The steel derrick is bolted together, and lock washers or self-locking nuts have been used. The lock washer introduces an extra part which is frequently conspicuous by its absence. A nut shaken loose and dropping 100 feet attains a velocity of 80 feet/sec. When stopped by the top of one's skull the consequences are apt to be disastrous, and that is one of the reasons why all workers in the derrick must wear adequate safety helmets.

The old single-cylinder steam-engine rated at 30 h.p. was first replaced by twin-cylinder steam-engines, boiler pressures were increased in order to cope with the power requirements of the deeper drilling, and later the internal-combustion engine was introduced. In order to cope with the increasing loads the brakes had to be increased in size and augmented by hydraulic or electric brakes, and at present the draw-works are well-engineered jobs, but they still bear hereditary traces of their simple origin.

The oilfield workers considered that the taking of safety measures to be a sign of weakness, but gradually they have been educated to see the wisdom of such precautions. At the same time operators found that

injuries were a costly business. This is particularly the case in the large modern drilling rigs which cost anything up to £1000 per day to run. A new man in a crew working in the tempo that is usual in the oilfields inevitably slows operations down to some extent, for the time being at any rate.

Most of the larger operators have a Safety Department, whose function is not only the formulation of safety regulations but also to train the workers in understanding them and their proper application. The operations on the oilfield are very complex, sometimes hazardous, and usually embody one or all of the three main categories of engineering—civil, electrical, and mechanical. In addition, there are the hazards attached to inflammable liquids and gases, the latter not infrequently being lethal.

Examples special to drilling and production operations can here be mentioned. In the drilling rig the derrick man has the most hazardous job. He is always working at a distance above the derrick floor, where a slip and a fall may easily cause fatal injury. Most of the time he works on the fourble board, some 80 feet above the derrick floor. In order to get there he can climb the ladder or "ride the elevators." Most operators forbid the latter method, but statistics have not shown that the latter method is more risky than the former, if proper precautions are taken. A derrick man's belt is always provided, and the derrick man must wear it when working on one of the platforms. The usual specification for the safety belt and the rope to which it is attached, is that they must stand a weight of 200 lb falling 5 feet. Almost invariably this is taken to mean that the fall is to be limited to 5 feet, since no directions ever appear to be given as to how the safety rope is fixed. A man dropping 5 feet attains a velocity of about 18 feet/sec. If the rope absorbs the energy developed by a 200-lb man travelling at 18 feet/sec by stretching 1 foot the average load on his body will be 3600 lb ! and the result a badly injured if not a dead man in the belt. By suitably attaching the rope to a wire line strung between the derrick legs about 14 or 16 feet higher and allowing 3 inches slack, the derrick man gets all the freedom of movement he needs, and his maximum drop will be about 6 inches. In the author's opinion the code does not go far enough if it prescribes only that a safety belt of certain physical properties must be worn by all working above the derrick floor, and the method of fixing the safety rope should also be prescribed. It is difficult in all cases to set down clearly, in words only, the safety technique, and where this could be made clear by a simple sketch or drawing, it would appear necessary to supplement those special cases with illustrations.

A comprehensive electrical safety code for the oil industry has already been drawn up by the Institute, and safety codes for the other ramifications of the industry, drilling and production, refining, transportation, and marketing, are being drawn up. In general, it will be found that such a code can in the main be divided into two categories—namely, safety measures which are so vital that they must be complied with and therefore are requirements which must be rigidly adhered to. The other category contains safety regulations which are recommendable but not so vitally essential.

The API standards indirectly contribute to safe operations. As instances can be cited the derrick standards which give the manner in which the safe

load capacity of derricks should be calculated for ordinary and high-tensile steels, also how the position of the dead line tie down affects the safe-load capacity of the derrick. The API specifications for valves and fittings call for certain test pressures for cold-working pressures—except in one range the former are twice the latter. The Institute of Petroleum have not formulated standards for oilfield equipment, and it may therefore be essential to embody in the safety code recommended safe practice in the selection of equipment.

In compiling the safety code for the drilling and production section, the following headings have been taken for the original basis.

A. *General Safety Code for Oilfields*

1. Open or enclosed premises in oilfields, including permanent or temporary dwellings.
2. Site clearance, roads, and transportation.
3. Machinery, plant, and structures.
4. Workshops, garages, welding plants, and stores.
5. Fire hazards due to inflammable liquids, vapours, and gas.
6. Drainage and pollution.
7. Noxious gases.
8. Explosives and explosive magazines.

B. *Special Code for Drilling and Cleaning Operations*

1. The drilling rig, erection, running, and dismantling.
2. Exploration and exploitation drilling.
3. Well control equipment.
4. Bringing into production.
5. Clean-out and deepening operations.

C. *Special Code for Production Work*

1. Well servicing and well pulling work.
2. Individual pumping units.
3. Multiple pumping units and pumping powers.
4. Pull-rod systems.
5. Gas and oil separators, production stations, and production pump stations.
6. Field storage tank farms.
7. Gas, oil, and water lines.
8. Compressor stations.
9. Gasoline extraction plant.
10. Oil-line pump-stations.

Of course some of these will overlap and will make it necessary to have cross references where this happens, and it is the intention that each section should in itself be complete so that the persons interested can, in their own section, find all the recommendations for their particular branch of the operations. It will be noted that this list refers only to actual operations and not to a particular technique. It is for this reason that it

is suggested that further safety recommendations on technique are necessary, as will be clear from the following example.

Wells have not infrequently been lost and life endangered by the surface string having been cemented too high, and although the casing and the well-head equipment were quite capable of shutting-in the deeper high pressures, the ground itself was unable to do so. A blow-out can then occur at a distance from the casing, and sometimes this distance can be quite appreciable. Where such conditions arise the cause is frequently a fault crossing the hole below the surface string, thus offering a passage of lower resistance to the surface. From this it is obvious that the first string should be so cemented and fitted that it will be capable of controlling any pressures that may be encountered while the hole for the next string of casing is being drilled. Normally the pressure at any depth is equal to the head of a salt-water column to that depth, but there are cases where the pressures have been considerably higher. The code distinguishes between "normal" and "abnormal" wells, and it would appear desirable to make recommendations for safe technique in the drilling operations.

The extent to which the code should go in its recommendations is a question repeatedly debated, and an instance for which no safety code could cater may be quoted. In the switchgear room of a power-station a switch cubicle was moved out for repair. In this position the cubicle was disconnected from the bus bars, and the switchgear could be worked on with safety. The re-connexion to the bus bars was effected by replacing the cubicle, after its door had been closed, through three bayonet sockets. A gentleman of an inquiring mind bent a piece of wire and worked this through one of the sockets to see whether he could contact the bus bar. He did, but unfortunately did not live to proclaim how the result of his investigation had profited him. No safety code will protect such a man from his folly—only a strait jacket and a padded cell would avail.

In the formulation of the Safety Code it is suggested that the following general lines form a working basis :—

1. That certain safety measures are axiomatic and must be complied with.
2. That the formulation of the safety recommendations should be such that men of goodwill and good sense can interpret them and apply them effectively.
3. That the safety code should not attempt to cover more than the ordinary reasonable hazards, since it is impossible to protect the hare-brained from their folly.
4. That humanitarianism and economics be blended happily to secure the greatest protection for life, limb, and property at the lowest cost.

I.P. SAFETY CODES APPLICATION TO REFINING

By F. Mayo (Fellow)

Introduction

As far as is known no other body has previously sponsored the preparation of a model code of safe practice for petroleum refineries. Nevertheless, the policy of safe design and safe practice has naturally received very considerable attention by the operating companies. Each has established its own principles and practices; many of them being written into engineering design manuals, operating manuals, safety regulations, and the like, and some of them being accepted as unwritten laws. The principles which have been established, although often independently evolved, are largely identical, since they are fundamental. Since, however, refineries differ in the types of plant installed, lay-outs, organization, and in many other details, the implementation of safe practice has been achieved by various routes, and individual company rules have differed in their degree of severity. The desirability of setting up a comprehensive code capable of application on a common basis to all concerns is therefore evident.

Refinery Sub-committee

The Engineering Committee invited and appointed the following to form a sub-committee who would deal with the preparation of the Refinery Code :—

Dr F. Mayo (*Chairman*)
T. T. Maclean (*Deputy Chairman*)
R. D. Brownlee
J. W. Vincent

The sub-committee held their first meeting on July 14, 1949, and meetings have been held at approximately monthly intervals since that date to further the drafting of the Code. Owing to a change of duties, J. W. Vincent resigned his membership in April 1950, and his place has since been ably filled by P. M. Griffiths. Mr Vincent gave very valuable assistance to the committee.

Relevant Literature

Whilst not attempting here an exhaustive literature survey, it may be helpful to mention some existing publications having a bearing on refinery safe practice.

First, there is the Factories Act 1937, which in Parts I–VI provides British legislation covering health, safety, and welfare. The Ministry of Labour and National Service publication of "Factory Orders" gives Regulations and Orders authorized under the Factories Act 1937 and other Acts. These rules cover many aspects affecting working conditions and workshop practice, and also provide certain safety regulations for boilers, steam and air receivers, and chemical works.

The Association of British Chemical Manufacturers issued in 1929 and 1930 their "Safety Rules for Use in Chemical Works." Part I covering "Model Rules" was revised in a third edition published in 1947. Certain items of this code can be applied to petroleum refineries, but in general its application is very limited, since it was not designed with refineries in mind.

Regulations regarding pressure vessels are provided in the API/ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases, the ASME Boiler Code, and recently the provisional BS.1500 (1949) Code for Pressure Vessels for use in the Chemical and Allied Industries.

Recommendations regarding tank spacing and oil-retaining wall requirements were made in a U.S. publication "NFPA Flammable Liquids Ordinance L4."

In addition, there have been sundry API publications which provide valuable refining safety guidance, in particular the "Accident Prevention Manuals."

General Form and Scope of Code

Owing to the potentially wide application of the Code, it was felt that it should be written as a general guide of safe practice, in the form of recommendations rather than as a set of rigid rules. Hazards were to be pointed out and recommendations made as far as possible on the basis of the minimum requirement necessary to ensure safe working. In certain cases, however, it was foreseen that it may be necessary to enlarge on specific items, and it may be desirable in these cases to make recommendations which more than cover the minimum requirement.

The following section headings have been designed to cover the scope of the code :—

1. Introduction.
2. Definitions.
3. General precautions.
4. Loading and Unloading :
   - (*a*) Ships and small craft;
   - (*b*) Road and rail cars;
   - (*c*) Packages.
5. Bulk storage of petroleum and its products.
6. Process units.
7. Plants handling dangerous chemicals.
8. Laboratories.
9. Filling liquefied petroleum gas into containers.
10. General refinery services.
11. Fire-fighting services.
12. Breathing and rescue apparatus.
13. Miscellaneous.
14. Index.

So far, Sections 1 to 6, excepting sub-sections 4(*b*) and (*c*), have been provisionally drafted. Each section has been broken down into the respective items which it is thought should be included under the section headings. These items may require revision and additions in Sections 7 to 13.

1. *Introduction*

(1) The purpose of the code.
(2) Local and national laws.
(3) The use of dangerous chemicals and solvents.

Apart from explanatory notes on the code itself, it is thought desirable, in the Introduction, to call attention to the necessity to check any existing laws either national or local which may pertain to a refinery. Also, although a separate section dealing with the use of special chemicals and solvents is contemplated, it is not thought practicable at this stage to cover in detail all the many chemicals which a refinery uses. Accordingly, it was felt that a general comment on the use of chemicals was called for at the outset.

2. *Definitions*

In all codes of this nature, a list of definitions of the terms used in the rules or recommendations is necessary to avoid ambiguity in interpretation and to afford the maximum brevity in drafting the code. Following the experience and advice of the Engineering Committee after the compilation of the Electrical Code, the task of compiling a list of definitions of terms likely to be used in the main draft was undertaken as a first step. This list will be subjected to final review with any necessary additions and deletions after the main draft is completed.

It is pertinent to point out here that for the purpose of the Code (all sections) petroleum products have been classified according to their flash points; Class A products having flash point below 73° F; Class B flash point between 73° and 150° F inclusive; and Class C flash point above 150° F.

3. *General Precautions*

(1) Entry of persons and vehicles to refinery.
(2) Permits.
(3) Inspection of plants equipment and instruments.
(4) Housekeeping.
(5) Offices and buildings.
(6) Medical services.
(7) Reporting of accidents.
(8) Safety department.
(9) Hygiene.

This section is comprised of general items applicable to all refineries which do not come under any particular chapter heading. Nevertheless, they are of importance and require due consideration as part of the safety code.

The question of "permits to work" has given rise to some interesting discussion in committee. It is apparent that the number of permits and certificates in current use among various refineries is legion. These are given all manner of titles such as, safety certificate, gas-free certificate, clearance certificate, fire permit, welding permit, work permit, and the like.

It is believed that all necessary permits to work can be covered in six categories, viz. :—

(1) To work above ground in buildings or open spaces.
(2) To work in enclosed vessels, culverts, or drains.
(3) To use naked flames or portable lights with trailing leads.
(4) To excavate.
(5) To work on electrical feeders or distributors.
(6) To resume normal operations.

To standardize and simplify methods, it may be possible, with appropriate wording, to combine the above on to one form. As a necessary preliminary to items 1, 2, 3, and 4, a gas check is usually necessary. Most refineries make this a separate step with the issue of a " gas-free certificate." Here again, it may be possible to make provision for this preliminary step in the overall " permit-to-work " form.

Recommendations on housekeeping and offices and buildings will be kept to a minimum and in fairly general form, since these are subjects which are not peculiar to refineries. It is felt that to go into any detail here would lead us outside the scope of the Code.

4. *Loading and Unloading*

(a) *Ships and Small Crafts*

(1) Use of ship's steam.
(2) Use of ship's galley.
(3) Fire extinguishers.
(4) Blanking exposed flanges.
(5) Earthing for static.
(6) Testing flexible hoses.
(7) Signals.
(8) Tugs and small craft.

Safety procedures for loading and unloading ships appear to be established on fairly uniform lines. Difficulty in case of queries, however, has sometimes arisen over the respective responsibilities of the ship's master and berthing or dock master, particularly in the case of chartered vessels. In this respect, practice varies from place to place. It cannot be overemphasized that loading and unloading is a joint affair, requiring the full co-operation of ship's master and dock master and their respective crews. Generally, the ship's master is regarded as having final authority over all operations and fittings on his vessel, even though the shore crew may have made the various connexions and joints for pumping aboard his ship. Likewise, the dock master has final authority over all shore arrangements and operations. Whilst recognizing the final authority of the ship's master aboard his vessel, it is nevertheless usual and necessary for the dock master to satisfy himself that the arrangements aboard ship for pumping are adequate and safe.

It should be recognized that the dock master has this authority to inspect the arrangements on board. In case of dispute over safety arrangements, either ship or shore master can refuse to pump or receive oil pending settlement at a higher level of authority. It should be pointed out, however, that in some cases usually involving small craft owned by the shore company, the ship's master is responsible to the shore authorities, and local arrangements are in force whereby the dock master takes complete

charge of all operations both on shore and on board as soon as the ship is berthed, and remains in charge until it is cast off. The extent of authority of the ship's master and dock master needs to be clearly established by the company or companies concerned as a preliminary to the application of safety considerations.

(b) *Road and rail cars*
(c) *Packages*

Although included in the refinery section of the Code, since most refineries have activities in these respects, these subjects are more particularly a marketing activity. Accordingly, the Marketing Sub-Committee's recommendations will be referred to here, and modified only if and where necessary to conform to any special requirements which may be necessary due to practices carried on within a refinery's boundaries.

5. *Bulk Storage of Petroleum and its Products*

(1) Siting (spacing) of, and oil-retaining walls for, tanks.
(2) Fire-fighting equipment.
(3) Cleaning and gas-freeing tanks.
(4) Construction of tanks.
(5) Platforms, escape ladders, bridges, and hand-rails.

Section 11 covers fire-fighting generally. In Item 2 above, it was thought desirable to cover such fire-fighting equipment which is peculiarly used for bulk storage and may be regarded as a necessary permanent adjunct to the bulk storage. Under Item 4, attention will be directed to some of the constructional features of the tanks involving safety, *e.g.*, manhole doors, cleaning doors, vents, materials. attachment of cone roofs. Other items call for no special comments, save that here again recommendations of Refining and Marketing sub-committee overlap and will require co-ordinating.

6. *Process Units*

(1) Distance between plants.
(2) Oil-retaining walls.
(3) Fire-fighting equipment.
(4) Control-room fittings and doors.
(5) Equipment inspections.
(6) Gas-freeing vessels.
(7) Permits to work.
(8) Safety devices and discs.
(9) Blowdown systems.
(10) Protecting walls round furnaces.
(11) Gas and oil firing.
(12) Gas pockets.
(13) Marking of underground pipelines and cables.
(14) Platforms, escape ladders, bridges, hand-rails.
(15) Fire-proofing of structures.
(16) Drains.

As in Section 5, " Fire-fighting equipment " is also included in this section, and similarly it is intended to cover here such equipment as is necessary, particularly for the protection of process units. This will include steam spears and first-aid fire-fighting equipment such as is used by the process operators rather than by the fire-brigade personnel.

Under the heading " Distance between plant " (Item 1) it is not thought practicable to make definite recommendations regarding spacing as can be specified for tankage. It was thought well, however, to include mention of this matter with some general remarks on the considerations involved.

7. *Plants Handling Dangerous Chemicals*

(1) General.
(2) Clothing and equipment for personal protection.
(3) Safety equipment.
(4) Precautions when using cast-iron, alloy, and non-metallic fittings.
(5) Blending and handling TEL.

As was pointed out in the remarks dealing with the introduction, it has not been our intention to cover detailed precautions peculiar to all the numerous chemicals which may be met within the refinery industry. It may, however, be thought desirable to extend this section later. At this stage, a list of chemicals and solvents encountered will be given, and we are proposing to make recommendations on special housekeeping precautions, protective clothing, safety equipment such as baths and showers, eye-baths, etc. Most refinery plant and equipment is fabricated of steel or steel alloys, but when dealing with plants using chemicals it is not unusual to encounter cast-iron, alloy, and non-metallic fittings. These may be of a brittle nature, or susceptible to thermal shock, or again may fatigue after rough mechanical handling, vibration, or after prolonged exposure to certain chemicals, and attention will be called to the precautions necessary when using these materials.

The Ethyl Corporation have very thoroughly established the techniques and procedures necessary for the safe handling of tetra-ethyl lead in their published literature—reference will be made to their recommendations, but it is not intended to duplicate these as a section of the Code.

8. *Laboratories*

In this section recommendations will be made with respect to the lay-out and fittings of a refinery laboratory which require consideration in the light of safe practice. It will probably also be desirable to include certain recommendations concerning laboratory procedures and techniques.

9. *Filling Liquefied Petroleum Gases into Containers*

Panel 2 of the Liquid Fuel Gas Industry Committee has already accomplished some exceedingly useful work in establishing and standardizing filling procedures for liquefied petroleum gases. It is planned to invite the collaboration of this Committee when writing up this section of the Code. Mr J. Wilding, Secretary of the Committee, has already indicated his willingness to co-operate on this matter.

10. *General Refinery Services*

(1) Drains.
(2) Refinery effluents and separators.
(3) Refinery flares or torches.
(4) Sludge and refuse disposal.
(5) Locomotives.
(6) Refinery motor transport and mobile plant.
(7) Telephones.

There are a number of precautions to be observed from the point of view of fire risk in the design and installation of refinery drains and oil separators, and in the disposal of effluents. These factors will receive attention in this general refining services section. Refinery flares and torches are necessary to ensure the safe outporting of any surge or excess requirement of combustible gases. They require special care in lighting and to ensure that they remain alight. Similarly, other items listed in this chapter require appropriate precautionary measures for safe operation which will be covered in the Code.

11. *Fire-fighting Services*

12. *Breathing and rescue Apparatus*

13. *Miscellaneous* (including) :—

(1) Welding and burning.
(2) Repairs to packages.
(3) Safety tools.

14. *Index*

Owing to the nature of the subjects to be dealt with in Sections 11 and 12, it may be desirable, and perhaps necessary, to depart from the itemized recommendations form of presentation, and adopt a more descriptive text; otherwise, these latter sections call for little comment.

I.P. SAFETY CODES
APPLICATION TO MARKETING

By R. L. SARJEANT

ON the marketing side, the same basic principles that govern the question of safety on the production and refining sides apply equally when one comes to consider the safe lay-out and operation of marketing installations. However, conditions are somewhat different in that such installations handle only finished products, whereas on the production and refining sides the products handled are in many cases in a more dangerous condition, and, moreover, the very nature of the work carried out, particularly at refineries, is such as to necessitate the utmost care in the provision of adequate safety distances. Intermediate cuts are frequently produced and stored temporarily for blending purposes, and these in some cases have appreciably higher vapour pressures than any product stored at a marketing installation. In addition, such products may come from the process plant to the refinery storage tanks at temperatures a great deal above the ambient air temperature, and these factors result in a higher concentration of inflammable gases in the vapour spaces of such tanks and a greater persistence of an inflammable vapour trail when vapours are discharged from such tanks, whether due to breathing or the filling of the tanks.

The following were appointed by the Engineering Committee to form a Sub-Committee to deal with the drafting of the Marketing Code :—

R. L. Sarjeant (*Chairman*)
G. S. Ambrose (*Deputy Chairman*)
H. King
A. H. Stephenson

In addition, G. A. Vickers and J. R. Winscombe have attended a very large proportion of the Sub-Committee's meetings, and their advice and assistance have been invaluable.

The following list of chapter headings shows the comprehensive scope of the work. In addition, a list of definitions will be embodied and various appendices included to amplify, where necessary, data and recommendations appearing in the Code itself.

Foreword.

Chapter 1. Layout of installations and depots.
Chapter 2. Extensions of installations and depots.
Chapter 3. Maintenance and repairs to installations and depots.
Chapter 4. Plant and equipment : (*a*) Mechanical.
(*b*) Electrical.
Chapter 5. Buildings.
Chapter 6. Operation of installations and depots.

(*a*) Receipt of bulk cargoes.
(*b*) Loading of bulk cargoes.
(*c*) Types of packages.
(*d*) Cleaning of packages.
(*e*) Filling of packages.
(*f*) Repairs to packages.
(*g*) Handling of packed products.
(*h*) Miscellaneous operations, including ethylizing and other blending.
(*j*) Welfare.

Chapter 7. Fire precautions and appliances.

Chapter 8. (*a*) Transport of petroleum in bulk. Road and rail cars.
(*b*) Transport of packages.

Chapter 9. Liquid gas storage and handling.

At the time of preparing this paper, thirteen meetings have been held, and Chapters 1 to 5 (except Chapter 4) have been prepared in draft form, and Chapter 6 is under consideration. Chapter 4 is still in the discussion stage.

Foreword

This refers to the diversity of petroleum regulations in existence in various parts of the world, some of which date back to the earliest days of the industry, when little was known about the subject except that petroleum in some of its derivatives was highly inflammable. To be on the safe side somewhat excessive safety distances were specified. In view of present-day knowledge of the risks involved, and in particular the marked improvement in the design and construction of storage tanks and other equipment in the intervening years, it is apparent that such safety distances can in some instances be modified and rendered less onerous with perfect safety.

Chapter 1. Lay-out of Installations

Following the large number of experiments carried out in various parts of the world to determine the persistence of vapour trails, *i.e.*, the maximum distance from the source at which the concentration of vapour is sufficient to support combustion, it is recommended that in the case of Class A petroleum the spacing between tanks shall be the diameter of the smaller tank or 50 feet, whichever is less. The distance between a tank and storage shed or building, or between a tank and the outer boundary of the installation shall be the diameter of the tank or 50 feet, whichever is less. As from the operational angle it is frequently desired to group a number of small tanks together, it is further suggested that this may be arranged in groups not exceeding 3000 water tons aggregate capacity, the spacing between individual tanks in the group being governed solely by constructional and operational conditions. Furthermore, the distances quoted may be reduced in the case of floating-roof tanks and others of specified design, and do not apply to buried or semi-buried tanks, the spacing of which may be governed solely by constructional convenience. Above-ground tanks should be bunded, either singly or in groups, in the latter case the total capacity not to exceed 40,000 tons. For single tanks the capacity of the bunded area should be 100 per cent of the tank capacity, but where two or more tanks are in the same enclosure the capacity should be equal to the capacity of the largest tank plus 10 per cent of the combined capacities of the remaining tanks. No bunding is required for tanks which are completely buried or mounded over.

Whilst from the safety angle it is unnecessary to follow the above spacing in the case of tanks containing Class B petroleum, changes in local demand frequently entail, sooner or later, the interchange of tankage for Class A and Class B petroleum, and with this in mind it is recommended that the same spacing should be adopted for both classes.

Tankage intended for Class C petroleum is unlikely to be upgraded to Class A petroleum, and the spacing between tanks and between tanks and boundaries may be governed solely by constructional convenience. No bunding is necessary.

In the case of a bulk depot, which for the purposes of this Code is defined as a storage area to contain not more than 1000 tons of petroleum products of all grades in bulk, in view of the smaller risks involved the above-recommended spacing may be materially reduced. For Class A petroleum the spacing between tanks may be governed solely by constructional and operational conditions. A minimum distance of 6 feet between operational buildings and buried or semi-buried tanks is suggested, and for vertical and elevated tanks this should be increased to 20 feet. The distance between tanks and the outer boundary of the depot should be not less than 6 feet in the case of buried or mounded-over tanks, and for tanks at ground level this distance should be the tank diameter or 50 feet, whichever is the less. For elevated tanks the minimum distance to the boundary should be 20 feet, irrespective of tank diameter.

In the case of Class B petroleum, the above distances may be reduced to the limit of constructional convenience, except that here again if at any

future date it may be desired to change over a tank or tanks to Class A petroleum the above recommendations should apply.

For Class C petroleum all distances are governed merely by constructional convenience.

Chapter 2. Extensions to Installations and Depots

Stress is laid on the importance of special precautions being necessary when outside contractors are employed whose personnel are not necessarily familiar with the normal precautions adopted in such locations. Where extensions are to be carried out in areas subject to the safety distances specified in Chapter 1, written permission from a competent authority on the site is to be obtained before power-driven vehicles, plant, or equipment may be brought to the area in question. For major construction work the provision of temporary barbed wire fencing to prevent straying of contractor's personnel is recommended. The importance of written permits signed by a competent authority before any work is commenced in certain areas, locations, and conditions is stressed, likewise the issue of written permits or authority to resume normal operations. Emphasis is also laid on the additional precautions necessary when " hot work " is to be undertaken, and it is recommended that no such work should be permitted within 50 feet of a tank containing Class A petroleum, 25 feet in the case of Class B, and 10 feet in the case of Class C petroleum. Any working tanks coming within these distances must be completely emptied of their contents, blanked off, and a gas free certificate obtained before the written permit to work is issued.

Chapter 3. Maintenance of Installations and Depots

Similar precautions to those outlined under Chapter 1 are recommended, with additional recommendations regarding the use of gas-masks for the preliminary inspection of the inside of tanks and other locations liable to contain an accumulation of gas; the use of gas-masks for minor repairs inside a tank or similar vessel, and other precautions to be taken whilst such work is in progress. The issue of gas-free certificates before major work in such locations is undertaken is recommended, and in the case of tanks which have contained ethyl-treated spirit reference is made to the comprehensive instructions issued by the Associated Ethyl Corporation and the importance of adhering strictly to these regulations is stressed.

In the case of electrical repairs, the importance of isolating completely any circuit embodying flameproof equipment is emphasized.

Recommendations are made regarding written advice to operating personnel who may be indirectly concerned, *e.g.*, pump-house personnel should be notified when any pipeline repairs are to be undertaken, repairs to switchboards should be notified to personnel concerned with the circuits in question and permits to resume normal operations should be issued on completion of the repairs.

Reference is made to normal commercial practice in the case of mechanical plant and equipment, such as periodic inspection and testing of boilers, other pressure vessels, lifting tackle, and any other equipment the failure

of which might result in danger to life or limb. The importance of complying with relevant Government regulations, local regulations and by-laws, Factories Acts, and the like which may be in operation in the area concerned is also stressed.

Chapter 4. Plant and Equipment: (*a*) Mechanical; (*b*) Electrical

This chapter is still in the discussion stage. The electrical side has been very largely covered by the Electrical Code already issued. On the mechanical side the types of mechanical equipment normally in use are of ordinary commercial quality and are no less inherently safe because they are within a petroleum installation or depot than they would be elsewhere. Effective machinery guards for all moving parts are recommended wherever feasible and, particularly their immediate replacement after the machine has been overhauled and adjusted. The design of tanks and other containers as such hardly comes within the purview of this Code, but the adequacy of manhole diameters to give ease of egress in an emergency, the provision of hand-railing to roofs, ladders, and staircases and similar details directly affect the safety of personnel, and will be dealt with by appropriate recommendations.

Chapter 5. Buildings

Buildings are divided into two main categories, viz :—

(1) Office and administrative buildings.
(2) Operational buildings.

The former are normally situated at a safe distance from the operating sections of the installation, and need not, therefore, conform to any special specifications in regard to fire-resistant construction. Their recommended location is adjacent to the main gates with access from the roadway, so that visitors to the office do not enter the working area of the installation.

Operational buildings are subdivided into three groups covering :—

Group 1. Power-plant, fire stations, and the like, to be situated in a safe area so that their components can be safely operated in the event of a fire in another area.

Group 2. Filling sheds, reconditioning shops, pump-houses, packed oil stores, which constitute a possible fire hazard, should be spaced not less than 50 feet apart.

Group 3. Maintenance shops, service buildings, and boiler-houses which may include open fires should be located in safe areas.

Operational buildings should be of fire-resistant materials, including doors and windows. Adequate ventilation for Group 2 buildings is stressed, and doors should be so placed and constructed as to provide a ready means of escape in the event of fire. Electrical equipment should comply with the Electrical Code. Oil stores and filling sheds should have their floors sunk 6 inches below ground level, or the whole floor be surrounded with a 6 inches sill, to control possible spillage.

Chapter 6. Operation of Installations and Depots

This chapter covers a very wide field which can be touched upon only briefly at this juncture. Under "Receipt and Loading of Bulk Cargoes" the importance of close co-operation between ship and shore personnel is stressed. Strict adherence to all port and installation fire regulations must be observed. Where hoses are used they should be hydraulically tested not less frequently than every twelve months to 10 per cent above the working pressure and superficially examined every time they are used. Hoses used for Class A petroleum in which the electrical bond is built in must be tested at regular intervals for electrical continuity. Similar tests should be carried out in the case of separate earthing connexions when used. Records of all such inspections and tests should be kept. Flanged connexions should be secured with clamps to enable operators to break joint rapidly in an emergency.

The remaining chapters are, in the main, of a non-controversial nature, but any views put forward will be welcomed by the Committee, and will doubtless be of assistance in their future deliberations.

Discussion

F. Mackley: During the last twenty-eight years or so I have developed, as has everybody here, I imagine, quite a healthy respect for the properties of petroleum, and in particular the property of combustibility in air and that of forming explosive mixtures; those are the two properties on which the prosperity of the petroleum industry mainly depends. Unfortunately, they are the two very properties which happen to cause us most embarrassment in our particular spheres of winning, refining, and handling petroleum and its products.

I know that the work which has been done so far on safety is regarded by Mr Sturgess and his collaborators as but a part of the whole; much still remains, and it must be done before he and his Engineering Committee and the sub-committees can draw up the final Code. But already one or two things come out quite clearly.

The first is that the anxieties and fears which many of us have suffered in the course of our duties in the past and which, incidentally, have been shared to a very large extent by the authorities who allow us to establish our installations and refineries in certain parts of the world, are probably—and I emphasize "probably"—relatively groundless.

Secondly, it would appear that the odour test as a means of detection of explosive mixtures is relatively useless, and many of us could have had a good rest while the various operations proceeded in the normal way. At one particular refinery of which I was in charge I suffered great anxiety with regard to the operations of filling rail tank cars. The filling gantry was situated 25 or 30 ft from a main roadway, and there was much stopping and starting of motor vehicles; and on a quiet summer day one could literally see the vapours, or the reflection of them, pouring over the roadway. I tried to get the gantry moved to what I considered to be a safer position, and in order to support my case I had tests taken from time to time along the roadway, but at no time was I able to show that there was a 100 per cent

explosive mixture. I was disappointed, because I felt there was a nigger in the wood pile somewhere; I was afraid we should be caught out by a terrific bang.

Such experience tends to support the evidence brought forward by Mr Sturgess on the various tests which have been made throughout the world. I personally welcome this addition to our knowledge, because it is only by the acquisition of knowledge that we can arrive at a sensible code of safe working and at the same time tend towards better economy in the construction of our installations and refineries.

I have one or two criticisms to make, however. For instance, in the tunnel tests, which are in effect the only controlled tests which have been performed—I believe I am right in saying that the others have been subject to natural forces—I would have liked to have seen a series to include a controlled dynamic source of vapours rather than a static source. Quite clearly the tests were designed for a specific purpose, and in so far as that is concerned I think they are above criticism. Nevertheless, I think the tunnel tests would have been far more informative, and I think the results would have been far different, if we could have had a dynamic source. I hope Mr Sturgess will be able to arrange something on those lines, because I feel that under those scientific conditions of test we shall obtain valuable results and we shall not be liable to be misled by a variety of spot tests under natural conditions, which ultimately might lead us somewhat astray.

The spacing of tanks has been mentioned by Mr Sarjeant, and one must agree, of course, that the spacing as indicated by the spread of vapours is quite a reasonable one. On the other hand, are we prepared, from the fire-fighting point of view, to have Class A major storage so closely spaced? In the event of a major fire breaking out in Class A storage with the suggested spacing, we may have very great difficulty in controlling fires in other tankage.

I welcome the knowledge that those gentlemen who are working on this problem will try to arrange for further tests at higher filling rates for main storage tanks, because there again I think the higher filling rates will show quite a different picture from that shown by the relatively low rates of filling which have so far been examined.

Finally, I would take the opportunity to congratulate Mr Sturgess and his co-workers, not only on the manner in which these papers have been prepared, but also on the courageous spirit in which this very important work has been undertaken. We must realize that in the development of the Code they are preparing the ground for developments maybe ten or fifteen years hence, when the practices they now recommend may become common, not only in Britain, but also throughout the world. We all appreciate that the knowledge they have already put before us puts us in a better position than we occupied in the past to conduct our activities, and a better basis to build on for the future.

A. C. HARTLEY: In suggesting safety measures I think one most important thing is that the protective devices themselves should be absolutely safe. By way of illustration I would recall an accident which occurred some years ago. A piping hand-rail on a tank was painted when the tank was painted, and it looked perfect. Corrosion had occurred

inside it, however, so that it became thin and gave way when a man was relying on it. That caused a very bad accident and such occurrences make people nervous of safety measures.

We must try to keep in our minds the conditions which start a fire. I think it is quite true to say that we cannot ignite gasoline; we can only ignite the vapour which is formed. A fire or explosion depends very much on temperature and on the time of contact of the ignition device.

Mention has been made by Mr Sturgess of the FIDO job, and I agree entirely with what he has said. The sight in the pump-houses was most astonishing. The N.F.S. pumps were the only types that could be used and were available; they had slightly improved glands, etc., and they were extremely effective. In some of the experiments it was most astonishing to see petrol vapour coming out of the holes in the pipe, under pressure. The holes were only 4 to 6 inches apart, and yet on occasions it was very difficult to light the vapour coming from them. We could see the vapour coming out of the continuous line of holes to a height of 1 or 2 ft; with difficulty we lit the vapour over one or two of the holes, and it took a long time for the flame to spread along the pipe. Afterwards we learned that it was a matter of temperature, that it was difficult to light the gas because it was to all intents and purposes refrigerated; it needed preheat. On one occasion I burned my hand rather badly. Very carelessly I tried to light one of the jets coming from the pipe; it was near one which had been tried for several minutes, so that the pipe and the ground around it were warm, and there was a tremendous flash. That emphasizes that we have to consider temperature when determining safe distances between stored explosive materials.

As showing also the importance of time of contact, in connexion with FIDO it was argued that if an aeroplane, when landing, ran through the line of flame, it would light up. We tried experiments and found that, if an aeroplane went through that line of flame at 40 or 50 m.p.h., it would not ignite; there was not the time to produce the combustible mixture and to light it.

Different spacing of tanks in Classes A and B has been suggested. But are there not sometimes cases where a Class B may be more dangerous than a Class A? In some cases a more dangerous explosion may arise with kerosine than with gasoline, because the gasoline becomes too rich to worry us.

I think these Codes are excellent and that those responsible have made a very fine effort. It is very important to arrive at reasonable figures for all these safety limits. An example of its importance is to be found in arriving at the bearing pressure on a foundation; if you play too safe you are wasting a tremendous amount of money. So it is with the calculation of safe distances between the containers of explosive materials; by arriving at the correct distances we shall save a lot of money. I do not suggest that we should go quite so far as a consulting engineer of whom I once heard; he said that he would be wasting the money of most of his clients unless he had one or two failures with others!

J. J. VAN DE STADT: I am wondering whether it would be possible to use non-flameproof electric drive in areas of refineries which are only remotely

dangerous, if we recognize officially the existence of remotely dangerous areas in the refineries as well as in the oilfields.

It seems to me that in well-ventilated pump-rooms the danger is not very great, so that it might be agreed that, if a remotely dangerous area is well ventilated, we could allow the use of non-sparking motors and even non-sparking switchgear. That would mean the saving of an enormous amount of money. If that matter were investigated the consequences might prove to be very important.

D. R. HOWGILL: I should like to draw attention to Chapter 2 of Mr Sarjeant's paper, where he recommends that tanks which contain Class A petroleum should be emptied if within 50 ft of another tank on which "hot work" is being carried out, that tanks for Class B petroleum should be emptied if within 25 ft of such work, and tanks for Class C if within 10 ft. Whilst appreciating the reasons for recommending those precautions, I feel that in most marketing installations and depots they would mean putting practically the whole of the tankage out of operation when "hot work" was in progress. I think the precaution that is necessary is to control any free gas; provided a regulation is made that the tanks adjacent to any on which "hot work" is carried out must not have petroleum pumped into them while that work is in progress, and that the necessary screening and normal precautions are taken, that should suffice.

DR W. L. F. NUTTALL: About three years ago I attended a meeting of the Petroleum Committee of the International Labour Organization, a sub-committee of which dealt with safety in the petroleum industry. Naturally, the International Labour Organization, when dealing with safety, is concerned mainly with the prevention of accidents to workers in the industry. I would ask Mr Sturgess whether his Committee have attempted to assemble data concerning accidents which have actually occurred to workmen, with a view to determining where accidents to workmen are most prevalent.

C. A. A. ROGERSON: I was glad to hear Mr Sturgess emphasize the care that should be taken during the gas freeing of tanks which have contained spirit. This is indeed necessary, and I should like to see precautions carried a step farther and ban the gas freeing of tanks in still atmospheres.

I can recall a fire which occurred during gas-freeing operations when all normal precautions had been observed. There was practically no air movement, and gas issuing from the tank was diffused all over the installation. It was ignited by a charcoal stove in the garden of one of the native compounds outside the installation, flashed back to the tank, causing explosions in godowns sited some 270 ft on the far side of the tank.

It therefore seems to me that this point should be stressed to the utmost in the new Code.

F. E. WARNER: I suggest that the references made to the distances within which explosions can occur point to the need for more research work, perhaps wind-tunnel work, on the actual mechanisms by which an explosive mixture can be carried a distance away from the source of vapour. There are obviously two mechanisms at work, one being the normal diffu-

sional mechanism and the other a mass-transfer mechanism related to the induced turbulence, depending on the wind around the point of exit of the vapour. Wind-tunnel experiments would perhaps enable you to isolate under actual still-air conditions the diffusional mechanism. The more volatile hydrocarbons give less risk than the more dense hydrocarbons, because the diffusional mechanism is faster in the case of the volatile hydrocarbons than in the case of those having much greater density.

We have studied this question partially, not in connexion with petroleum vapours, but with the vapours of coal-tar products.

Railway " hydrocarbon " containing *cyclo*pentadiene was found to give detectable concentrations of vapour at very much less distance from the tanks from which we were pumping it than was the case with toluole. We carried out our experiments under still-air conditions, the worst conditions we could find, and even then the detectable concentrations were limited to very small distances. Even with toluole we got down to within 20° of the lower explosive limit at 20 ft or thereabouts. The rate of pumping from the tanks was about 4500 gallons per hour. Under the lightest wind it was extremely difficult to obtain any detectable concentration of vapour at more than 20 ft away from the tank.

J. A. AINSWORTH : May I refer to Mr Sarjeant's suggestion that buried or mounded-over tanks might be placed 6 ft from the boundary? I suggest that it is the opening of a tank which is the danger point; there is no suggestion in the paper with regard to it, but I suggest that it might be covered.

With regard to the bunds, and so on, I take it that regard will be paid to any drainage system which may be within the bund areas on the site or premises. In cities we are concerned to ensure that the main drainage system is protected against any outflow from places where large quantities of petroleum are kept.

Probably underground tanks provide the safest form of storage, provided they remain sound. Has consideration been given to the question of prevention of corrosion of tanks?

H. E. F. PRACY : I should like to make a suggestion to the sub-committee which deals with refineries; it is that they should cover the H_2S hazard. Many of us are concerned with Middle East crudes at the present time; those crudes have very high sulphur content, and under certain conditions—mild cracking conditions, and so on—it is possible for them to produce a very light, high-vapour-pressure spirit saturated with H_2S. In those conditions we have to insist that the sampling of the spirit is done by people wearing gas-masks. The diffusion of H_2S is very different from the diffusion of petroleum vapour normally and, unfortunately, in its dangerous concentrations we cannot smell it.

D. S. HUDSPETH : When I was asked whether I could think of a contribution which could usefully be made from the point of view of the manufacturers of tanks and other vessels I could think of very little indeed, apart from such obvious safety measures as the provision of hand-rails around tanks. I rather hope that we do our job very well and when an accident occurs, it is not put down to a bad storage tank or vessel or to bad fittings.

However, accidents may arise where it is not the fundamental design or the manufacture of the plant which is at fault, but rather there has been faulty maintenance—either inadequate maintenance or perhaps maintenance which is not entirely appropriate to the job. For example, we are familiar with the fact that storage tanks and vessels are regarded as being very static things in the structural sense or from the maintenance point of view. They are painted regularly, as one would paint a building; but the sort of maintenance that goes into a mechanical job does not go into these tanks and vessels. For example, I doubt whether nowadays any safety valve on a boiler almost anywhere in the world is neglected; I think that is one of those obvious things which are subjected to fairly rigorous examination. On the other hand, although the regular examination of the pressure valve on a storage tank is also very necessary, because the tank is thought of in structural terms the pressure valve does not receive the attention that is given to the safety valve on a steam-boiler.

Again, the sealing ring of the floating-roof tank does the same sort of job as the piston-ring in a reciprocating engine. It is usual for users to take a good look at reciprocating engines every now and then and to alter or replace piston-rings, and so on; but the sealing ring of a floating-roof tank does not always get that sort of attention, again largely because the storage tank is regarded as a static item of equipment.

I think the maintenance of such items as those mentioned above should be stressed very much in the Code, because it is something which should be done, although it does not seem to be immediately obvious to maintenance staffs.

One learns much more about safety problems from accidents which have occurred than from general discussions or from experiments which are conducted with a view to finding out the causes of accidents. As manufacturers I think we should put out a plea that we should be drawn more often into discussions or post-mortems on accidents which have occurred, even though they may not have been due to faulty design, but may have been due to faulty maintenance. If we are brought into such discussions, those of us who are concerned with the design of vessels and fittings would have safety requirements more in mind than we may appear to have, if my reaction can be regarded as an example.

My company is connected with the oil-refining industry and with the coal-gas industry. In our fabricating work for the coal-gas industry we have to observe regulations of the same sort as those in the oil industry. Before we can enter vessels in order to do repairs the vessels have to be properly cleaned out, and so on, and I was wondering whether this Institute's committees are taking note of regulations which obtain in other industries. I believe the Institution of Gas Engineers has a safety code which gives guidance on procedure in the coal-gas industry; even though this deals with gases lighter than air, there may be some useful guidance for the Institute's committees, particularly where the building of tanks is concerned.

To sum up, I think that we as manufacturers do not know a great deal about safety problems, but we should like to know more. It has been very welcome to hear reference in the discussion to post-mortems on accidents. We should like to hear of them, and if we can help more in connexion with safety measures in the design of tanks we should like to do so.

MAJOR W. CRAWFORD: The Explosives Department of the Home Office is very interested in the preparation of a Safety Code. We have a draft Model Safety Code which we send out to various local authorities when requested, covering the storage of petrol. It covers the three main stations —the filling stations, the small distributing stations, and the larger storage places at refineries, etc. I shall be only too pleased to send Mr Sturgess a copy of this Model Code if desired. We do not agree entirely about some of the safety distances and the capacity of the bunds which are put forward in the papers; but I hope that when you have drafted your Code we shall be able to have a copy of it.

With regard to accidents, we may be able to help your various committees, because the Home Office has a complete list of all accidents with petroleum spirit on licensed premises where one or more persons have been injured. Those accidents are reported to us under the provisions of the Petroleum (Consolidation) Act, 1928.

J. H. WHITBY: I am pleased to hear that the Home Office are interested in this Model Code, because I feel that the guidance which has been given to local authorities gives them so much latitude that we do not quite know how we are to instal the tanks in various districts. In many cases, in built-up areas, we instal 30-ft × 9-ft tanks; in some cases we want to build them above ground but the local authorities want them below ground in sand; others want them below ground in puddled clay, and in another case I know of, the local authorities want us to put the tanks below ground in a concrete pit and with puddled clay. So that we do not quite know where we are; if our Model Code covers these items, and if the Home Office take notice of it, I think we shall go a long way towards standardization. I would add that even in built-up areas some local authorities will accept the tanks in a concrete pit at ground level.

V. BISKE: Mr Sturgess has stated that the explosimeters used in his tests were all checked before the trials. It would be of considerable help if, in the proposed Code, an appendix could be included giving the recommended procedure for the verification of instruments of this type as there is, I feel, an undue tendency to take the continued satisfactory working of such apparatus for granted.

As regards the classification of petroleum products. Is perhaps the grouping of all materials flashing below 73° F in one class unduly wide, and would there be any justification for subdividing this class according to the vapour pressure of the material?

J. W. BURRILL: I should like to bring forward an aspect which I do not think has been mentioned so far, and also make a plea on behalf of those who will have to use these Codes. We all agree the production of a Code involves immense labour, but it is a task which is very necessary, and it is undoubtedly the intention that afterwards the Code will be used to good purpose. We have to remember that, after the Codes are produced, other people have to apply them. Their task should be made as easy as possible.

I have had some experience of this matter, both in writing and applying Codes, and I would suggest the Code be written in perhaps two forms or in

two portions. We should have "regulations" and "recommendations," because if we put into a Code clauses which are not actually regulations, *i.e.*, which need not be complied with as a minimum requirement, but which are merely recommendations, then we shall find in many cases, in the stress of getting the job done, these clauses will not be carried out. If there are requirements which are not put into effect, then the whole Code very rapidly becomes discredited or disregarded by workmen and staff. To minimize this possible source of trouble, I suggest we should be very careful to separate the clauses into two categories, *i.e.*, into regulations and recommendations.

I would also suggest that, after the Code is drafted, you should look at every regulation from the viewpoint "is this likely to be done?"; if it is not likely to be done, then leave the regulation out. Do not include regulations which *might* be done, but only those which *ought* to be done and which *must* be done.

T. RICHARDS: I would like to support very heartily the comments by Mr Burrill. I can claim some little knowledge of the preparation and application of Codes and Regulations, and it is a fact that a great deal is gained in their application by making clear the regulations which *shall* be enforced in all circumstances as distinct from recommendations for consideration which arise out of experience.

Regulations, of course, should only be made when all the factors having an influence on the requirements have been considered, not least the economic aspect. We have heard reference made to underground storage, and it is not a bad idea to bury your hazards, but in certain circumstances, to follow this practice would not represent sound economics and the management on the site should be permitted the use of their discretion within the terms of a recommendation.

I should like to make three other suggestions. First, I would plead that the language of your document should be such that it will be understood by people who are not peculiarly and particularly identified with the business of producing, distributing, and marketing your products. As an example, I would refer to the code letters used in the draft to designate the three grades of petroleum products when dealing with storage. Unless they are made abundantly clear, even to the non-petroleum technical man, doubts will arise and confusion may result. It is surprising what a lot of ignorance exists outside your own sphere of activity!

Secondly, this document is mainly written round one aspect of safety, and very rightly so. It refers particularly to the hazard which comes to mind immediately one thinks of petroleum—fire and explosion. I do, however, make the plea that the drafting committees might consider going a little beyond the fire aspect of safety; there is a lot more to it than that; hand-rails provide a good example. You have bunding, within which you can discharge the material in your tanks if fires occur, but what happens to this material in the bunding, does it get out and if so where does it go? Someone else may get your problem later on if drainage is not given the careful planning it deserves.

Finally, I would say that those who are not directly in your business look to you for guidance. They have been doing that for a long time and have

been very well satisfied. You are concerned at the moment with the development of a safety code on a particular subject—petroleum hazards.

It will be of inestimable value to other industries outside your own particular sphere if the drafters will keep in mind the peculiarities of various industrial situations outside the industry with which they are immediately concerned. If they try to see the problems which might arise, not thinking only in terms of tank farms in connexion with storage, we are assured of sound guidance which will be gratefully received and, we hope, faithfully applied.

THE PRESIDENT: Before asking Mr Sturgess to deal with "questions" and to give a closing review of the discussion, I should like to stress again that this is a very vital and valuable piece of work which the Institute is doing. I want to thank on your behalf the permanent staff of the Institute and others who are helping these committees by taking care of the office administrative work, co-ordination, etc. Those of us who are closely in touch with this work do appreciate their help very much.

MR STURGESS: This has been a very interesting discussion, and I will touch briefly on various points which have been raised.

Reference was made by Mr Mackley to further tunnel tests. I cannot quite see the point he is making there. If you put a continuous supply of vapour into the end of a tunnel and drive it through, you will have the vapour coming out at the other end; but in ordinary operations the vapour is not enclosed in that particular manner. The tests we carried out, I agree, were on a static supply of casinghead gasoline, and the amount of vapour was regulated by the evaporation of the source. My own feeling is that, if we had a continuous supply of vapour coming into the tunnel at one end, it would emerge into a dangerous atmosphere at the other end.

I agree that these tests of ours are all spot tests, and the fact that you will find a non-dangerous atmosphere at a particular moment does not mean that you do not have a dangerous atmosphere there a short time afterwards. On the other hand, the tests made number 270, covering a big volume, and they all show the same trends. We have been trying to get some recording instruments for refinery research on the subject, but so far we have not been able to get them. When we do, we hope to be able to make more reliable tests than the spot tests already made.

With regard to tank spacing in relation to fire-fighting, the suggestion has been made that the tank spacings recommended in some instances are too small. That is a matter of opinion, of course. As to the spreading of fires from tank to tank, often you may have one tank on fire and you may have the vents of another alight, but I think that only infrequently will you have another tank set on fire. Possibly there have been instances of that occurring; but the tanks usually have sprinklers on them to keep the adjacent tanks cool, and I think that is a factor we had in view.

The point made by Mr Hartley concerning the jets on the FIDO installation is a very good one; I remember the difficulty when he tried to make the jets ignite successively. I should be interested to know whether he has data on the actual temperature of the gases coming out, for that would be useful.

He also makes the point that some of the kerosines produce a more dangerous atmosphere above the liquid than is the case with gasoline. I think that is a point very well raised and that we should reconsider it. We have covered it partially, for our recommendation is that Class B installations which are interchangeable with Class A should be spaced at the same distances as Class A.

The problem of dangerous areas in the refineries in relation to electrical equipment was raised by Mr Van de Stadt, and that was discussed very extensively when the Code was being prepared. So far as pump-houses with electrically driven pumps are concerned, I think the practice of many companies is to keep the switchgear in a safe area, which means that they do not have to use expensive flameproof equipment for the switchgear, and the pump motors alone are flameproof. That was brought up in Committee when we were framing our recommendation on that point, and I will see whether the Committee will look into it again.

Mr Howgill raised the problem of " hot work " in tanks; that is a good point and one which the Marketing Sub-Committee might re-examine. I imagine we have all had experience of having to do " hot work " at distances of less than 50 ft from main storage tanks; provided we have an experienced man on the job, that we put up a screen between the tanks, and that we do not carry on the work while pumping into the adjacent tank and while vapour is being displaced, we are fairly safe.

MR SARJEANT: In view of what Mr Sturgess has said, I may mention that this particular point was considered by my Committee only yesterday, and we do contemplate putting a very strongly worded footnote into the regulations, that notwithstanding the distances specified, when they cannot be observed, for reasons of operation, for instance, they may be relaxed provided the appropriate precautions are taken; some of the precautions will be listed, such as screen walls, the presence of fire brigades, and so on.

MR STURGESS: We have been asked by Dr Nuttall whether we have collected data on accidents. So far we have not. I am a member of the Industries Safety Committee of the I.L.O., and they have asked for data on accidents to be sent to them; there is an Industries Committee dealing with all I.L.O. matters, and I have asked that Committee whether they have data on accidents which could be submitted to the I.L.O. I am very glad to hear from Major Crawford that the Home Office have details of all accidents in Britain, including those which have occurred in the petroleum industry.

It has been recommended by Mr Rogerson that no gas-freeing of tanks should be carried out in still atmosphere. That is probably a very sound recommendation where you have an oil installation in any crowded area, and I have tried to emphasize that, so far as safety distances are concerned, it is impracticable to legislate for the gas-freeing of tanks. As he has pointed out, a flash took place from 220 ft.

Further tunnel experiments on the diffusion of vapours at higher densities were suggested by Mr Warner. I am afraid that is a little beyond me. But if he would care to write to the Institute we will see what can be done to help in this matter.

The question of siting underground tanks 6 ft from the boundaries was raised by Mr Ainsworth, and it was suggested that something should be recommended concerning the positioning of the vents on the tanks. I think that is a very sound suggestion, because it is generally practicable to carry the vent line a further distance away from the boundary of the installation.

Another matter is that of the provision of sills on warehouses and the disposal of drainage. A number of petroleum regulations require the provision of a sill to contain the whole volume of the oil stored in packages in the warehouses. There are two matters I would mention in that connexion. Anybody who has tried to get packages out of a warehouse having a sill 3 ft high takes a poor view of it. The other matter is that during the recent fighting in China we have had a few warehouses set on fire, and I have asked our engineers what exactly happened, whether a tremendous volume of liquid flowed out of the warehouses. Actually, when packages catch fire they expand and explode, so that a lot of liquid is thrown around from some of them; but they do not all go up at once, and when the fires have been put out there are many packages remaining intact, with the oil inside them. The flow of oil from the burst packages is not equal to the total amount of oil contained in the whole of the packages in store.

The problem of drainage has been looked after by the recommendation that oil interceptors should be fitted on the drainage systems of all installations and depots to prevent the drainage getting into the public drains.

The point made by Mr Pracy concerning the H_2S hazard at refineries will be passed on to the Refineries Sub-Committee; I feel it is very important.

Mr Hudspeth has emphasized the importance of the maintenance of things such as breathing valves, sealing rings, and so on. That is very important. As to whether or not the manufacturers of the equipment are responsible, I think we should like to ask them to pay special attention to welded fittings and to welding in general. There is a certain amount of welding work—especially on floating-roof tank seals of the old hangar type—on the seal, where the welding has obviously been done by apprentices because the job was thought to be unimportant; one can almost flick it off with the thumb-nail, as one would a piece of sealing-wax, and I would ask all manufacturers of that type of equipment to ensure that, not only the butt welds, and so on, are well carried out, but also the miscellaneous welding which they may think is unimportant, but which does really play a large part.

We shall be very pleased to receive a copy of the Code which the Home Office have prepared for the assistance of local authorities, as mentioned by Major Crawford. One speaker has complained that the Code is too wide and that it does not tie things down specifically. I think that is the British way of doing things, and I am not altogether certain that it is not rather a good way; we do not wish to tie people down too specifically. On the other hand, it is desired to give them a general idea of what is required.

It has been urged that we should draw up our Code on the bases of both regulations and recommendations. That has been done already; but we would emphasize that when the Code is issued it will have no legal significance unless, of course, it is adopted by particular authorities. We are dividing the Code into those two categories.

The very good point was made that we should not put into the Code things which will not be done. We shall try to follow that line.

Mr Richards has urged that the Code should be made comprehensible to the layman. That point is well raised. We have Classes A, B, and C petroleum, which are what the man-in-the-street calls petrol, paraffin, and fuel oil respectively; we shall try to cover that point.

He also mentioned that we should look beyond the fire risk; I think the papers presented do indicate that we are looking very much beyond the fire risk.

The other point Mr Richards was trying to make, I think, is that in a chemical works there may be a tank storing petroleum, so that we need to make regulations for the storage of petroleum in tanks elsewhere than in petroleum installations. I think it is a little difficult to cover every place where petroleum may be stored, but I think the general sense of the Code, if interpreted intelligently, can be applied where petroleum is stored in consumers' premises. We will consider whether it is possible to cover the point, but I am not too certain about it.

Vote of Thanks

On the motion of the President, a special vote of thanks was accorded Mr Sturgess, not only for his handling of the discussion, but for all the work he had done in connexion with the preparation of the Codes.

RESTRAINTS ON THE EXPANSION OF VERTICAL TANKS UNDER LIQUID HEAD

By Peter Kerr (Fellow)

Summary

Formulæ are developed for the correction when necessary of tank tables for the restraining effect on expansion exerted by the tank bottom and roof, by buttstraps, and by horizontal and vertical seams.

Introduction

The analyses given below confirm or correct certain conclusions reached by the author from practical measurements on tanks. In each section the author's previous conclusions are set out, and then compared with theory.

Equations given below allow convenient calculation of the effects of these restraints on tank capacities; some of the results are described as negligible, a term requiring definition, since negligibility is always relative to some standard previously chosen. The author believes that for large tanks it is fairly easy to secure accuracies of about 0·01 or 0·02 per cent of the tank's capacity, at least in undistorted parts of the tank, but that excessive practical difficulties soon beset any attempt to better these accuracies. A correction is therefore described below as negligible if at most it can only amount to a fraction of 0·01 per cent of the tank's capacity.

The intention of the paper is to clear certain ground which, in the author's opinion, should be cleared, and so far as he is aware, has not been cleared before. Most readers will agree that there is a technical limit to the precision conveniently attainable in tank tables; the author's estimate of this is adopted as a standard of comparison ready to hand, without discussion of its merits or demerits otherwise. Whatever standard is chosen, there should, of course, be consistency in the handling of corrections; it would be illogical to dismiss relatively large corrections and retain relatively small ones. Commercial as well as technical considerations bear on the standard of accuracy to be adopted in practice; but such matters are not discussed. Basic formulæ used are taken from " Formulas for Stress and Strain," by Professor R. J. Roark, second edition, twelfth chapter, and references such as " R–10 " are to the tenth case discussed in that chapter.

The author's conclusions are that it is only in preparing tank tables of high precision that the effects of these restraints need be considered. At these precisions the effect of the tank bottom, of buttstraps, and of the roof may need consideration, this depending in all cases on the size of the tank and in the two last on its construction. Restraint at seams appears to be always negligible.

Free Expansion

Defining free expansion as that which would occur in a cylinder free from the effects of neighbouring discontinuities, this may be calculated from

$$dR = p \,.\, R^2/E \,.\, t \quad . \quad . \quad . \quad . \quad (1 : R\text{–}1)$$

in which dR is the change in radius R of the cylinder under the radial pressure p, t being the thickness of the cylinder walls and E Young's modulus for their material. Here E will be taken as 29×10^6 lb/sq. inch for structural steel, when p must be expressed in lb/sq. inch, while dR, R, and t are in inches; dR is positive outwards.

The formula has the alternative form

$$dR = s \,.\, R/E \quad . \quad . \quad . \quad . \quad . \quad (2 : R\text{–}1)$$

in which

$$s = p \,.\, R/t \quad . \quad . \quad . \quad . \quad . \quad (3 : R\text{–}1)$$

is the hoop membrane stress. Since R/E is substantially constant for any one tank, it follows that changes in radius are proportional to hoop membrane stresses.

The formula does not apply to vessels in which the internal pressure produces longitudinal tension in the sides. The sides of a tank are in vertical compression, since the lower plates support the weight of the upper; but this compression is present whether the tank is full or empty, and it may therefore be neglected in calculating tank expansions.

Bottom Angle-iron

Practical Conclusions

As a result of measurements made by two independent methods on tanks of various sizes, in both the filled and the empty states, the author concluded that relatively to the unexpanded vertical section, radial displacements under liquid head gave the expanded section of the sides near the tank bottom a shape substantially parabolic, the axis of the parabola being horizontal, and its vertex tangent to the tank side at a distance from the tank bottom which varied with the size of the tank and with the thickness of its side plates. The analysis below shows that the vertical section in question is not parabolic, but the theoretical curve is reasonably close to this.

The distance of the vertex of the curve from the tank bottom was difficult to measure with any precision, since it was a point of tangency, and this precluded satisfactory correlation of any reasonably small number of results with what seemed to be the important variables. Restraint could never be traced with certainty much beyond 4 feet from the tank bottom; and since the usual height of a course is about 6 feet, there were always levels towards the top of the bottom course which showed free expansions agreeing closely with the calculated figures. This conclusion is borne out by the theory below.

Analysis : Inward Thrust

For calculation of the effect, the side plates of the bottom course may be supposed to expand freely away from the rigid bottom angle-iron, and then be forced back into contact by a radial thrust of V_0 lb per linear inch applied inwards along the bottom edge of the course. The radial displacement caused by this thrust, negative since inwards, is then

$$dR = -V_0/2 \,.\, D \,.\, g^3 \quad . \quad . \quad . \quad . \quad (4 : R\text{–}10)$$

At contact, the sum of (1) and (4) must be zero, so that

$$V_0 = 2 \cdot D \cdot g^3 \cdot p \cdot R^2/E \cdot t \quad . \quad . \quad . \quad . \quad (5)$$

$$= \tfrac{1}{2} p \cdot w/q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

with $$2 \cdot V_0 \cdot g = p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

the meanings of the new symbols being given by

$$w^2 = R \cdot t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$q^4 = 3 \cdot (1-n^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$D = E \cdot t^3/4 \cdot q^4 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$g = q/w \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

In equation (9), n is Poisson's ratio, here taken from Roark as 0·26 for steel; neglecting small variations from steel to steel, $q = 1{\cdot}30$ is a constant for any tank. D, g, and w are constants for any one course; p lessens upwards in a tank containing liquid, but by taking an appropriate mean value it will be treated here as constant for any levels concerned.

Effect of Thrust on Hoop Membrane Stresses

The effect of the applied thrust is to produce a damped sinusoid variation in the hoop-membrane stresses in the side plates as one ascends, the effect being given by

$$s_x = -(2 \cdot V_0 \cdot g \cdot R/t) \cdot e^{-gx} \cdot \cos gx \quad . \quad . \quad . \quad (12 : R\text{–}10)$$

$$= s_0 \cdot e^{-gx} \cdot \cos gx \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

in which s_x is the hoop membrane stress at x inches above the bottom angle-iron, s_0 being the stress at its edge.

Resulting Radial Displacements

Taking $x = 0$ in (12) and substituting from (7),

$$s_0 = -p \cdot R/t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

This is the hoop membrane stress corresponding to dR in equations (1) to (4) above, and since, at least to the first order, radial displacements are proportional to these stresses, one may write

$$dR_x = dR_0 \cdot e^{-gx} \cdot \cos gx \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

in which dR_x is the radial displacement of the bottom-course side-plate inward from its freely expanded position, this at a distance of x inches above the bottom angle-iron, while $dR_0 = -p \cdot R^2/E \cdot t$ is its radial displacement, reckoned similarly, at the bottom angle-iron. The formula allows calculation of the radius or circumference to be expected under given conditions at any level above the bottom angle-iron. It is supported by the practical observation that apart from a short transition curve just above the bottom angle-iron, the section of a tank side under pressure is approximately parabolic.

Distance over which Restraint Effects Extend

If two restraining rings are spaced at least $x = 4/g$ apart, the effects of the one may be regarded as not extending into the effects of the other, so

that the effect of a single rigid ring, here the bottom angle-iron, may be neglected at any distance from the restraining edge exceeding

$$x = 2/g \quad . \quad . \quad . \quad . \quad . \quad . \quad (16 : R\text{–}9)$$

or

$$g \, . \, x = 2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Now $2/g = 2 \, . \, w/q = 1{\cdot}55\sqrt{R \, . \, t}$, so that x is largest when $R \, . \, t$ is largest. For the largest API standard tank, $R = 1008$ inches and $t = 1{\cdot}44$ inches; even for this tank the restraint of the bottom angle-iron does not extend more than 5 feet above the bottom, and this is less than the usual height of a side-plate. It follows that, in general, there will be a part of the bottom course of any tank that will expand freely, a point observed in practical measurements.

Form of Vertical Section of Side-plates

In Fig. 1, the values of $dR_x/dR_0 = e^{-gx} \, . \cos gx$ are plotted against gx,

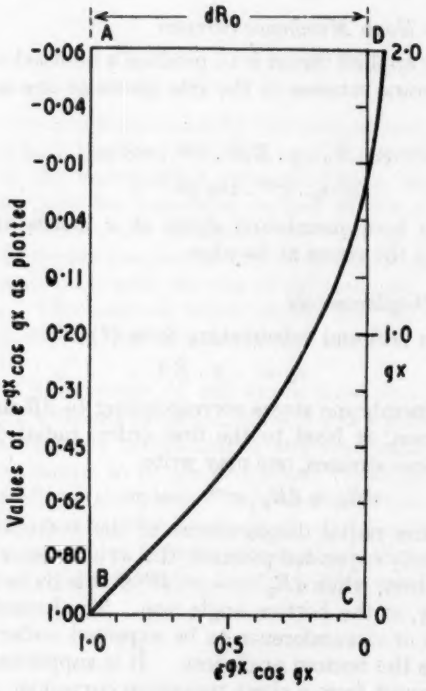


FIG. 1

so that the curve shows to these scales the shape under liquid head of the side-plates near the bottom of any tank. The area *ABCDA* is proportional to the volume which would have been added to that part of the tank's capacity by free expansion of the side-plates; and on the same scale the

area *BCDB* is proportional to the reduction in this volume through the rigidity of the bottom angle-iron. The area *BCDB* is given by

$$BCDB = dR_0 \cdot \frac{1}{g} \cdot \int_{gx=0}^{gx=\infty} d(gx) \cdot e^{-gx} \cdot \cos gx \quad . \quad . \quad . \quad (18)$$

$$= (dR_0/2 \cdot g)\Big[e^{-gx} \cdot (\sin gx - \cos gx)\Big]_{gx=0}^{gx=\infty} \quad . \quad . \quad (19)$$

$$= 0{\cdot}30 \cdot dR_0 \cdot 2/g \cdot \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

neglecting the sign; and since on the same scale

$$ABCDA = dR_0 \cdot 2/g \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

$$100 \cdot (ABCDA - BCDB)/(ABCDA) = 70\% \cdot \quad . \quad . \quad (22)$$

The conclusions are that the effects of angle-iron restraint may be neglected at any distance more than $2/g$ or $1{\cdot}55\sqrt{R \cdot t}$ inches above the bottom angle-iron, while up to that height, restraint reduces the actual expansion in volume to 70 per cent of the free expansion in volume.

Working Formulæ

These theoretical results require reduction to practical working formulæ for use in tank-table calculation. Fig. 2 shows a schematic vertical section of the side of the bottom course of a tank, *HAB* being the side before the *FDB* the side after expansion. The vertical line *GE* is drawn at such a distance y from *FDC*, the side as it would be under free expansion, that rectangle *GECFG* has the same area as *BCDB*. This leads to

$$y \cdot h = 0{\cdot}30 \cdot dR_0 \cdot 2/g \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

h being the height of the side-plate. Since $2/g = 1{\cdot}55\sqrt{R \cdot t}$,

$$y\% = 100 \cdot y/dR_0 = 46{\cdot}5\sqrt{R \cdot t}/h \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

This is roughly the percentage by which the calculated value dR_0 of the free radial expansion of the bottom course should be reduced to allow for bottom angle-iron restriction.

Formula (24) is reasonably convenient when tank diameters are measured but for circumference measurements, retaining h in feet, it is more convenient to have a formula in terms of C, the tank's circumference, also in feet, but with t in sixteenths of an inch. Making the necessary changes,

$$y\% = 1{\cdot}33\sqrt{C \cdot t}/h \cdot \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

in which y per cent is now the approximate percentage by which dC_0, the calculated free expansion of the circumference C of the bottom course, should be reduced to allow for restraint.

Further Correction of y *per cent.*

It is usual to take into the calculation of dR for the bottom course the pressure prevailing at mid-level of the course, since if the course is full, the resulting value of dR is a fair average for the whole course. From Figs. 1 and 2, however, it is seen that the mean pressure properly related to y per

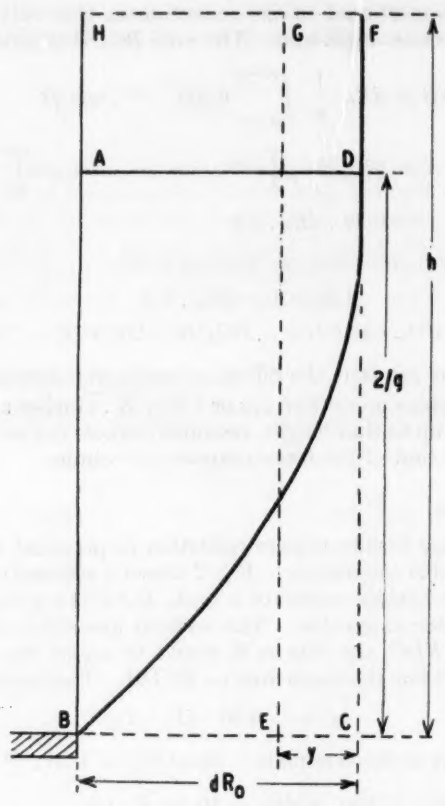


FIG. 2

cent is that at the mean height of the area $BCDB$ above its base BC, that is, at the level of its centre of area. This unfortunately may be a few feet below mid-level in the course, so that the approximate figure for y per cent should be corrected.

The centre of area lies above BC at $x = 0{\cdot}36/g = 0{\cdot}275\sqrt{R\,.\,t}$. In any one course, the free expansion dR is proportional to the head of liquid over that level. If T is the total height of liquid over the tank bottom, then $\bar{y}$ per cent, a better approximation, will be obtained by multiplying the calculated value of y per cent by $(T - 0{\cdot}275\sqrt{R\,.\,t})/(T - \frac{1}{2}\,.\,h)$. This ratio is not constant as the liquid rises in the tank, so that it should strictly be calculated afresh for each value of T required.

If, however, one is preparing the table for a tank of N courses, and in this calculating expansions cumulatively as the liquid reaches the top of each course, then by averaging the effect over all the courses concerned, $\bar{y}$ per cent, a sufficiently corrected average value, may be calculated from

$$\bar{y}\% = y\%\,.\,F_N \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

the values of F_N being obtained against N from

N	F_N	N	F_N
1	$2{\cdot}00 - 0{\cdot}012 \times y\%$	6	$1{\cdot}31 - 0{\cdot}004 \times y\%$
2	$1{\cdot}67 - 0{\cdot}008 \times y\%$	7	$1{\cdot}28 - 0{\cdot}003 \times y\%$
3	$1{\cdot}51 - 0{\cdot}006 \times y\%$	8	$1{\cdot}25 - 0{\cdot}003 \times y\%$
4	$1{\cdot}42 - 0{\cdot}005 \times y\%$	9	$1{\cdot}23 - 0{\cdot}003 \times y\%$
5	$1{\cdot}36 - 0{\cdot}004 \times y\%$	10	$1{\cdot}21 - 0{\cdot}003 \times y\%$

From formula (25) y per cent is first calculated, a mental multiplication and subtraction then giving F_N. If an eight-course tank shows y per cent $= 17$, $17 \times 0{\cdot}003 = 0{\cdot}05$, $1{\cdot}25 - 0{\cdot}05 = 1{\cdot}20$, and $17 \times 1{\cdot}20 = 20$ per cent. The free expansion of the bottom course, expressed either in change of radius, circumference, or volume, would then be reduced to 80 per cent of its calculated value in forming the table for the tank, this allowing for the restraint in question. The table of F_N is produced by calculation of the effect with the liquid surface at the top of each course, followed by suitable summations and averaging.

Horizontal Seam Overlaps

Practical Conclusions

Restraint at horizontal seams could not generally be traced at a distance of more than 4 inches above or below the plate edges, external or internal, at the seam. The author concluded that: (i) strappings or measurements closer than 4 to 6 inches above or below the seam edges were undesirable, since they included detectable effects of restraint; but that (ii) provided that this precaution was observed, the effect of these restraints on the capacity of any tank was in general negligible, either in percentage or in actual volume. Theory seems to bear out these conclusions.

Analytical Method and Result

Since the lower plate is usually thicker than the upper, the vertical section of a horizontal seam is usually asymmetric. Direct analysis of this asymmetric case would no doubt be more satisfactory, but it is troublesome; here the problem is approached in stages, the result being an approximate formula which may be used to bracket the asymmetric case. This approximate solution suffices, since the effect is negligible, on the standard adopted above.

Symmetrical Case

In Fig. 3 the side of a cylinder with a stiffening ring is shown in vertical section, (*a*) being the position of a side-plate before an internal pressure of p lb/sq. inch moves the plate outwards to position (*b*). At levels where expansion is unrestrained, the displacement dR_0 of the plate may be calculated from formula (1). The stiffening ring has a depth of c inches and a thickness of $2 \cdot t$ inches, with a cross-sectional area of $A = 2 \cdot c \cdot t$ sq. inches. The case obviously approximates to that of the overlap between two plates of equal thickness.

The inward thrust V_0' of the ring at its upper (or its lower) edge is given in lb per linear inch by

$$V_0' = (p \cdot w/q) \cdot (A - ct)/(A + 2 \cdot t \cdot w/q) \quad . \quad (27 : R\text{–}9)$$

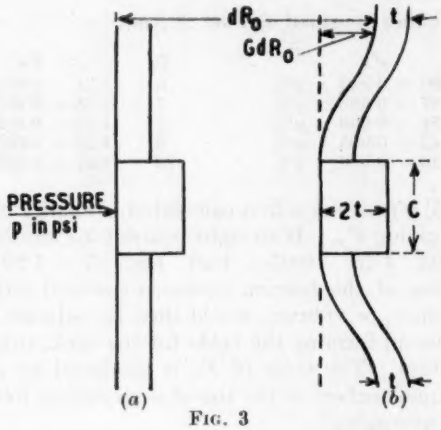


FIG. 3

in which, as in equation (9), $q = 1{\cdot}30$ and $w = \sqrt{R \,.\, t}$; and in the special case in which $A = 2 \,.\, c \,.\, t$,

$$V_0' = (p \,.\, w/2 \,.\, q) \,.\, c/(w/q + c) \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

$$= (p \,.\, w/2 \,.\, q) \,.\, G \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

G being a factor constant for the ring and independent of the pressure p.

Effects on Tank Capacities

It has been shown above in leading from equation (6) to equation (15) that to the inward thrust $V_0 = \frac{1}{2} \,.\, p \,.\, w/q$ corresponds the full inward displacement $dR_0 = -p \,.\, R^2/E \,.\, t$, and that inward displacements are proportional to inward thrusts, so that equation (15) may be rewritten here as

$$dR_x' = dR_0 \,.\, G \,.\, e^{-gx} \,.\, \cos gx \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

in which dR_x' is the radial displacement of the side-plate, inwards from its fully expanded position, at x inches above the upper or below the lower edge of the ring. G has just been defined, and the other symbols are as in equation (15).

The capacity lost through restraint above the upper edge of the ring up to $x = 2 \,.\, w/q$ is then proportional to $0{\cdot}30 \,.\, dR_0 \,.\, G \,.\, 2 \,.\, w/q$, see equation (20), while that lost at the ring itself above its mid-level is $dR_0 \,.\, G \,.\, \frac{1}{2}c$, so that dv, the total volume lost around the ring is proportional to

$$dv = dR_0 \,.\, G. \; (1{\cdot}20 \,.\, w/q + c) \quad . \quad . \quad . \quad . \quad . \quad (31)$$

If h is the height of a course, its total free expansion dV is proportional on the same scale to

$$dV = dR_0 \,.\, h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

The percentage z per cent of their free expansion lost through restraint around the ring to the two half-courses on either side is then

$$z\% = 100 \,.\, dv/dV$$

$$= 100 \,.\, (c/h) \,.\, (1{\cdot}20 \,.\, w/q + c)/(w/q + c) \quad . \quad . \quad . \quad (33)$$

The percentage z depends almost completely on c and h; it is so insensitive to changes in w/q that it is sufficient to take the average value

$$z\% = 115 \, . \, c/h \quad . \quad . \quad . \quad . \quad . \quad (34)$$

This is for a single course, or rather for the two half-courses above and below a seam.

Asymmetric Case

The thickness t_1 of the upper plate at a horizontal seam is usually a little less than t_2, the thickness of the lower plate. The expansion at such a seam may fairly be expected to lie between those for the two symmetric cases, in one of which both plates have a thickness t_1, and in the other a thickness t_2, both of these retaining the same overlap c as for the asymmetric case. Equation (33) shows, however, that the two bracketing cases are practically indistinguishable so far as their restraining effect is concerned, so that the asymmetric case need not be discussed separately.

Maximum Effect of Seam Restraint

Among all API standard tanks, the value of z per cent is greatest for their 168-ft ten-course tank with 72-inch-nominal plates. For the courses towards the bottom of this tank, the overlap c is $3\frac{3}{4}$ inches; but a fairer view of the effect for the whole tank is obtained by taking the mean overlap for all nine horizontal seams, and this is just under 3 inches. The mean height h of its courses is near enough 5·7 feet, so that $c/h = 0{\cdot}044$ and z per cent $= 5$ per cent at each of the seams. When the tank is full, the free expansion of each course is about 0·08 per cent of the course capacity, so that seam restraint alters the course's capacity by about 0·004 per cent; there are, however, nine seams and ten courses, so that the average for the tank is slightly less than this. No tank tables reach this degree of precision; in this maximum case, and so in all other cases, the effect on tank tables of horizontal-seam restraint is negligible.

Buttstraps

Practical Considerations

The author's experience with large and heavily buttstrapped tanks is not as wide as he could now have wished. The analysis below suggests an effect admittedly greater than he would have expected.

An important point is that when only one or two lower rings of a tank are buttstrapped, the effect may be notable when reckoned on the content of the ring, and yet be negligible when reckoned on the whole contents of the tank. The equations below calculate the effect as a percentage of the expansion which the ring would have shown had it been made of one continuous plate without buttstraps, so leaving the point just made to be dealt with separately.

General Course of Analysis

Two horizontal planes 1 inch apart vertically are supposed to cut an empty vertical cylinder at mid-level in one of its buttstrapped courses;

Fig. 4 shows part of this slice in plan, including along the arc AA' two buttstraps and the plate between them. An outward radial pressure of p lb/sq. inch is then exerted on AA', and the buttstraps and plate are supposed to separate and expand independently, the buttstraps taking up the arc BB', and the plate the arc DD'. Equal thrusts W are applied as shown, these forcing the buttstraps outwards and the plate inwards until their initial relative positions are restored along the arc CC'. The buttstraps and plate

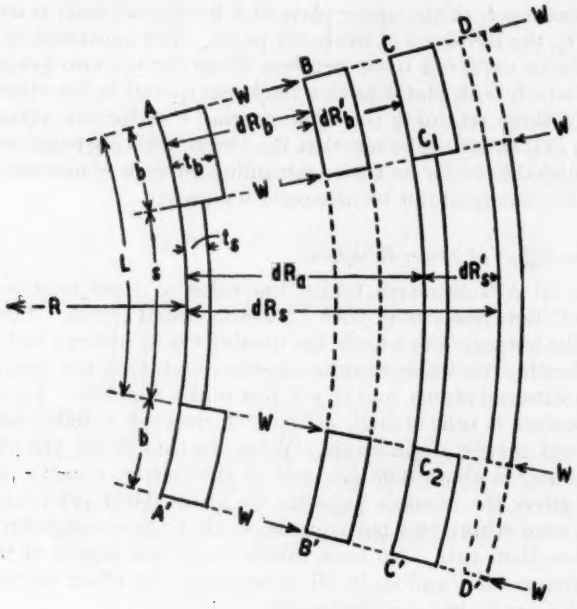


FIG. 4

are then re-united and released from the imposed thrusts, when the relative position of CC' is calculated.

This results in an approximate formula for the reducing effect of the buttstraps on the increased capacity which the course would otherwise have shown had its plates been continuous. On calculation, the main correction to this formula is found to be generally negligible.

As the section has been cut at mid-level in the ring, the restrained expansion found for it may be taken as the average for the ring, the expansion of the whole ring being calculated accordingly.

Approximate Analysis

The free radial expansion dR_s of the plate is

$$dR_s = p \,.\, R^2/E \,.\, t_s \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$

t_s being the thickness of the plate. If L is the whole length of the plate section, that part of it under buttstraps being b and the rest of it s, then if

the plate were continuous and free to expand, the total volume dV added by its expansion over the length L would be

$$dV = L \,.\, dR_s \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (36)$$

and restraint effects will be calculated below as percentages of this free expansion.

Similarly, if b is the breadth and t_b the total thickness, plate plus buttstrap, of the metal at the buttstrap, the free expansion dR_b of the buttstrap is

$$dR_b = p \,.\, R^2/E \,.\, t_b \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad (37)$$

so that

$$dR_b/dR_s = t_s/t_b \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (38)$$

The radial thrusts of W lb/linear inch applied to each side of the buttstrap are equivalent to an added radial pressure of $2 \,.\, W/b$ lb/sq. inch over the whole breadth of the buttstrap, so that this moves outwards under thrust by

$$dR_b' = (2 \,.\, W/b) \,.\, R^2/E \,.\, t_b \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad (39)$$

Similarly the plate, of length s, will move inwards by

$$dR_s' = (2 \,.\, W/s) \,.\, R^2/E \,.\, t_s \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad (40)$$

so that when the initial configuration is restored

$$s \,.\, t_s \,.\, dR_s' - b \,.\, t_b \,.\, dR_b' = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$

and since

$$dR_s' + dR_b' = dR_s - dR_b \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (42)$$

$$dR_s' = dR_s \,.\, (1 - t_s/t_b)/(1 + s \,.\, t_s/b \,.\, t_b) \,. \quad . \quad . \quad . \quad . \quad (43)$$

As a first approximation, to be considered again later, the plate may be supposed to take the shape of a concentric circular arc C_1C_2. The approximate radial expansion is then

$$dR_a = dR_s - dR_s' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (44)$$

and on substitution and rearrangement

$$dR_a = p \,.\, R^2/E \,.\, t_a \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (45)$$

if

$$t_a = t_s + b \,.\, (t_b - t_s)/L \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad (46)$$

This, with the other equations developed below, applies to a single plate and buttstrap; but the effect is obviously repeated around the ring, and so the equation holds for the whole ring as well as for each plate.

Outer and Inner Buttstraps

Buttstraps are usually doubled, and the circumferential breadth b_i and thickness t_i of the plate of the inner buttstrap are seldom the same as the corresponding quantities b_o and t_o for the outer.

In equation (46) t_s is the thickness and L the circumferential length of the side-plate, b the similar breadth of the buttstrap, while t_b is the total thickness, plate plus buttstrap, of the metal at the joint. Thinking of the joint for the moment as having a single internal buttstrap only, b may be written b_i, while $(t_b - t_s)$ is t_i. This leads to

$$t_a = t_s + t_i \,.\, b_i/L \,. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (47)$$

The physical interpretation of this equation is that if the total volume $t_i \,.\, b_i$ of the metal of the buttstrap were spread out evenly over the whole length L, and the resulting thickness of metal added to the plate thickness t_s, the slightly thickened plate so obtained would take up the same position, at least to a first approximation, as does the unthickened plate when the buttstrap is present.

To the same approximation, the metal in the outer buttstrap acts as if it were spread out evenly over the whole length of the plate. Since the effects of both buttstraps are small, they are additive; and this leads to a corrected value for t_a, given by

$$t_a = t_s + t_i \,.\, b_i/L + t_o \,.\, b_o/L \quad . \quad . \quad . \quad . \quad . \quad . \quad (48)$$

Taken with equation (45) above, this allows the combined restraining effect of the two buttstraps to be calculated.

Expansion Lost at Buttstraps

Expressed as a percentage of the free expansion dV, this, dv_b, is given approximately by

$$100 \,.\, dv_b/dV = 100 \,.\, (dR_s - dR_a)/dR_s \quad . \quad . \quad . \quad (49)$$

$$= 100 \,.\, (1 - t_s/t_a) \quad . \quad . \quad . \quad . \quad . \quad (50)$$

Correction of Approximate Solution

It has been assumed that the plate will take the form of a circular arc C_1C_2 in Fig. 4, but since the span between these points is great as compared with the thickness of the plate, the expansion of the latter should be calculated as that of a thin membrane. The necessary calculation has been made, and checked independently, as acknowledged below. Equation (50) is found to overestimate buttstrap restraint, but only slightly; written with the correction factor needed, it becomes

$$100 \,.\, dv_b/dV = 100 \,.\, (1 - t_s/t_a)(1 - s^3/16 \,.\, R^2 \,.\, L) \quad . \quad (51)$$

in which s is the circumferential length of that part of the side-plate not in contact with either buttstrap.

Assuming that the buttstrap design broadly follows that adopted by the API in their standard tanks, the equation has the alternative form

$$100 \,.\, dv_b/dV = 100 \,.\, (1 - t_s/t_a) \,.\, (1 - 1{\cdot}5/m^2) \quad . \quad . \quad . \quad (52)$$

in which m is the number of plates per ring. The effect of the corrective factor is that for tanks with 8, 9, or 10 plates per ring, the coefficient 100 on the right-hand side of equation (50) would be better written as 98; for tanks with 11 to 17 plates per ring, 99 would be better; while for 18 or more plates per ring, the coefficient is greater than 99·5.

Vertical Seam Overlaps

Practical Considerations

The author has seen many cases in which the cylindrical surface of the plate on one side of the seam is carried through without apparent break to the cylindrical surface of the other plate, much as if the seam were not there. In these cases the surface of contact between the plates sets itself

at a small angle to the cylindrical surface common to the two plates. The fact that the edges of the plates at the seam turn out quite sharply from the cylindrical surface is often readily detectable, though the angle is of course small. If two overlapping ends of a moderately thick rubber band are cemented together and the joint subjected to a slight pull, the cut ends of the band project, one on either side, from the continuous line of the band itself; apart from curvature, the effect is similar to that seen on the tank.

Many vertical seams, however, depart from this shape; they may project slightly from the cylinder, or be slightly re-entrant. The author is inclined to debit this to causes other than restraint at the seam, say to slight spreading of the plates when the hot rivets were driven, or to slight lack of horizontal register between corresponding rivet holes in the two plates. In no case seen, however, were these effects such as to necessitate any correction to the tank volume; it was therefore concluded that restraint at vertical seams is negligible. This conclusion seems to be borne out by theory.

Analysis

In its restraining effect a vertical seam overlap closely approaches that of a small single buttstrap of the same thickness as the plate, and with a circumferential breadth equal to that of the overlap. The effects of vertical seams in restraining expansion may therefore be calculated from the equations given above for buttstraps; but the effects are very slight in any ordinary case.

Top Angle-iron: Wind Girder: Roof Girders

General Considerations

Free expansion at the higher levels in the top course is small, since at these levels liquid head is never more than slight. Expansion is also reduced by the relatively thick plates normally used; that these are thicker than they need be for mere resistance to expansion is obvious when one remembers that the next lower course is often made of plate of the same thickness. Again, tanks are seldom filled completely full, since this would risk overflow. For these reasons the author has not measured the effects of restraints at these levels; it is now obvious that one or two confirmatory measurements might have been useful.

Angle-iron

The top angle-iron restrains expansion not only at its own level, but at neighbouring levels also. The restraint is severe; it cannot, however, exceed that of complete rigidity, and a maximum possible effect may be calculated on the assumption that the top angle-iron is rigid. The effect is seldom important.

Wind Girder

This may be dealt with similarly, rigid restraint being assumed at the lowest level at which any part of the attachments is fitted to the tank.

Roofs

Design varies, and this makes a general solution difficult; the most difficult case is that in which the roof is attached to side brackets extending down the tank sides. In specific cases the resistance of these brackets to expansion may be calculated; but this does not lead to the general solution required here.

Outline of Analysis Adopted

An approximation to all these effects may be obtained by supposing complete rigidity to affect not only the top of the ring, but to also extend to some chosen distance down it. As this involves an estimated rather than a calculated distance, the procedure may not always be satisfactory. By supposing rigidity to extend to the lowest point of the roof's side brackets, one may make sure that the effect is overestimated; if it is still negligible as compared with the standard of precision adopted in the particular case, no more is needed.

Analysis in Detail

It is supposed that an inexpansible ring is fitted around the top course at a distance d below its upper edge, and that all expansion under liquid head above that level is also suppressed. The restraining effect of the rigid ring then extends downwards to a distance of x inches from its lower edge, x being given as in equation (16) by

$$x = 1{\cdot}55\sqrt{R \,.\, t} \quad . \quad . \quad . \quad . \quad . \quad (53)$$

R being the radius of the course and t the thickness of its plates, both in inches.

If the tank is full of liquid, the mean pressure p_d in the top d inches is then

$$p_d = k \,.\, \tfrac{1}{2}d \quad . \quad . \quad . \quad . \quad . \quad . \quad (54)$$

d being the depth of the liquid and k a factor converting this depth into pressure in lb/sq. inch.

Similarly, the mean pressure p_x in the x inches below the rigid ring to which its restraint extends is

$$p_x = k \,.\, (d + \tfrac{1}{2}x) \quad . \quad . \quad . \quad . \quad . \quad . \quad (55)$$

while the mean pressure p_h over the whole course of depth h is

$$p_h = k \,.\, \tfrac{1}{2}h \quad . \quad . \quad . \quad . \quad . \quad . \quad (56)$$

Application of equation (1) then gives the corresponding radial expansions dR_d, dR_x, and dR_h.

The free expansion in volume of the course, dV, is then

$$dV = 6{\cdot}28 \,.\, R \,.\, h \,.\, dR_h \quad . \quad . \quad . \quad . \quad . \quad . \quad (57)$$

$$= K \,.\, h^2, \text{ say} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (58)$$

but on the assumptions made above, and through equations analogous to (57) and (58), there is lost from this a volume dv_g, given by

$$dv_g = K \,.\, (d^2 + 0{\cdot}6 \,.\, d \,.\, x + 0{\cdot}3 \,.\, x^2) \quad . \quad . \quad . \quad (59)$$

in which the coefficients of x and x^2 arise from equation (22), so that the percentage of the free expansion lost under the conditions assumed is

$$100 \,.\, dv_g/dV = (100 \,.\, d^2 + 60 \,.\, d \,.\, x + 30 \,.\, x^2)/h^2 \quad . \quad . \quad (60)$$

the equations also assuming implicitly that $d + x < h$.

If the main restraint is at the top of the course, then d is substantially zero; and if also the plate thickness is the usual $\frac{1}{4}$ inch, equation (60) reduces to

$$100 \,.\, dv_g/dV = 18 \,.\, R/h^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (61)$$

This is largest when R is largest; for a tank 168 ft in diameter with 72-inch plates, $100 \,.\, dv_g/dV = 3{\cdot}6$ per cent. Even with so large a diameter, this is small; and it may be concluded that if restraint is limited to levels close to the top of the tank, its effects may be neglected.

The effect, however, increases sharply as d increases, or as the assumed level of rigidity falls in the course. If, for example, in the tank just discussed $d = x$, expressed in volume the restraint is about 23 per cent of the free expansion.

Acknowledgments

The author is indebted to Mr J. Strawson for having drawn his attention to Professor Roark's book, for having lent a copy of this, and for expert comment; to Mr F. Barnes, Mr B. C. Ferguson, and Mr H. R. Holmes for verification of the equations given, and of a number of calculations omitted from the paper for the sake of brevity, and for their valuable and constructive comment.

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Oilfield Exploration and Exploitation

Geology

804. The radioactivity of sediments (4). E. N. Tiratsoo. *Petroleum*, Dec. 1949, **12** (12), 313–15.—The paper is concerned with radioactivity and petroleum itself. Experiments confirm that crude oils have no appreciable *gamma-ray* activity. Early reports of the increased radioactivity of oilfield brines have not been confirmed, although oil shales examined proved to be quite appreciably radioactive. This is possibly due to the potassium content of the shales.

The effect of radioactive energy available from clays, shales, etc., and its effect on the formation and modification of petroleum is considered. Energy derived from potassium may be considerable and important in petroleum genesis. R. E. P.

805. Regional aspects of Silurian and Devonian subsurface stratigraphy in Kentucky. L. B. Freeman. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (1), 1–62.—For some time

there has been a need for clarification of the regional stratigraphy of the Paleozoic sediments in the Central Interior region of the U.S.A.

Kentucky is strategically located, with the Cincinnati arch bisecting it and containing within its boundaries the southern end of the Central Interior basin, the western border of the Appalachian basin, and the north flank of the Ozarks extension which affected the facies distribution from Ordovician to at least Devonian time.

This paper is an attempt to reconstruct the geological history, during those periods, on a regional scale in order to show where the area now Kentucky fits into this general picture. Therefore, only the generalized geology is here given, with the hope that it may be useful to those working elsewhere in the Central Interior in solving the details of correlation. The minor problems of correlation which were troublesome in the past are solved in this regional interpretation, and it is believed that all of the problems which may arise in the area can be solved in this manner, with no more than minor adjustments.

The report ends within the basin of continuous deposition between Devonian and Mississippian, that is, within the thick black shale sequence on the western border of the Appalachian basin. E. N. T.

806. Mississippian and Pennsylvanian stratigraphy, Confusion Range, west-central Utah. L. Ogden. *Bull. Amer. Ass. Petrol. Geol.*, **35** (1), 62–82.—The Confusion Range, which is mapped on the Fish Springs, Utah, Quadrangle of the United States Geological Survey, is located near the east margin of the Basin and Range province. It is about 50 miles long and 10 miles wide. A spur called the Conger Range extends about 11 miles southwest from the centre of the main range. The climate is arid, and water is found at only three points in the range.

The stratigraphic column in the Confusion Range extends from Ordovician (?) through Triassic. Mississippian and Pennsylvanian strata were studied in detail, and one composite section was diagrammed.

Slightly more than 6000 ft of Devonian strata were recognized. They consist for the most part of massive, black limestone beds containing an Upper Devonian fauna. The massive limestone beds are overlain by shaly limestone beds that contain a *Cyrtospirifer* fauna.

The Mississippian system is represented by only 260 ft of strata, assigned to the Midridge formation, that appears to be correlative with some part of the Mission Canyon formation of Montana. No rocks of Burlington, Keokuk, Meramec, and Chester ages were found in the area.

The Pennsylvanian system consists of slightly more than 3700 ft of sediments that contain an abundant, well-preserved fauna of Morrow age. E. N. T.

807. Julesburg basin trend 90 miles long. P. C. Ingalls. *Oil Gas J.*, 7.9.50, **49** (18), 123.—Parallel to the east and southeastern edge of the Julesburg basin five areas produce from the Graneros (Cretaceous) sands on a trend 90 miles long. They are the Gurley–Huntsman oil and gas area (Cheyenne County, Nebraska), Armstrong area (Logan County, Colorado), Walker area, Merino area, and the Fort Morgan area (Morgan County, Colorado). All the pools are on seismic highs on a ridge, although not all the highs on this ridge have proved productive.

Structural relief has been slight in each success, and what appear to have been better closures have seemingly failed due to lack of proper sand development. Stratigraphic trapping may be an important factor in determining accumulation.

The regional dip is about 30 ft/mile to the west, while the ridge is associated with a slight reversal. Drilling results are confusing, and tests of intervals which yielded oil-saturated cores have at times given water only. G. D. H.

808. Arkansas has new field. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-76.—A-1 Miller Land and Lumber Co., Miller County, Arkansas, flowed 200 b.d. of 38·2° and 25 b.d. brine from the Rodessa at 6303 to 6312 ft. G.O.R. was 1300 : 1. C. A. F.

809. Tests sites anticline. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-78.—Nieta Peterson 1 is testing the Sites anticline in Colusa County, California. Three wells drilled previously on the structure, which is a steep chevron fold, found methane, probably in the Cretaceous. The Sutter Buttes field, 25 miles to the southeast, is producing Cretaceous gas. C. A. F.

810. Drilling outlook good in California. Anon. *Oil Gas J.*, 6.7.50, **49** (9), 93.—In the third quarter of 1950 about ten wells/month were expected to be drilled in South Cuyama, while increased drilling was likely at Morales–Clayton and Morales–Superior, also in the Cuyama Valley. The former had five producers in the 1850-ft sand.

Two new fault blocks have been found to yield oil in the Signal Hill area of Long Beach. In Signal Hill town site some sixteen wells have been plugged back and opened at a 2300-ft sand. On the southeast flank of Long Beach a 6400-ft oil sand was opened in June with a 900-b.d. 29°-gravity producer. A 5493-ft, 3500-b.d. well has been completed in the Belgian Anticline area. Southwest of the 500 to 600-ft Tejon Hills pool a 150-brl pumper has been completed at 545 ft in the Santa Margarita. G. D. H.

811. Cuyama discovery. D. H. Stormont. *Oil Gas J.*, 31.8.50, **49** (17), 43.—3 miles northwest of the Morales field a wildcat has given over 200 b.d. of 30° oil on the pump from 5644 ft. This may link with Morales to give a long narrow field producing from the Miocene.

Clayton has nine shallow pumpers. The Pliocene beds dip west to southwest below the east-dipping White Rock thrust. Lenticularity and the fault give closure. There is 150 to 300 ft of pay at 1800 to 2600 ft. Permeability averages 400 mD, and wells give about 100 b.d. G. D. H.

812. Oil and gas developments in the Atlantic coastal plain during 1942. E. W. Berry, *Petrol Tech., Sept.* 1950, **2** (9), 166.—A 300-ft well near Springfield, South Carolina, is supposed to be active, but no further drilling has been done on Fanny Collins No. 1, south of Conway. A rig between Winton and Harrellsville, North Carolina, has stood at about 1300 ft since May 1949. The well is at or near basement. G. D. H.

813. Colorado oil may be new oil discovery. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-76.—Koenig Ashby 1, Logan County, Colorado, flowed 70 brl/hr of dry 40° oil from 5250 ft. 425 brl were produced in the first 24-hr test. C. A. F.

814. Illinois field gets new production zone. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-72.—A third potential pay has been found in the new Ellery West area, Wayne County, Illinois. 1 Fisher Community found good saturation in the Aux Vases and Rosiclare at 3223 to 3241 ft and 3322 to 3230 ft. C. A. F.

815. Why doesn't the Salina basin produce? P. C. Ingalls. *Oil Gas J.*, 3.8.50, **49** (13), 95.—1 Campbell in Cloud County, Kansas, was located after surface, core-drill, seismic, and magnetometer studies. It was drilled through Pennsylvanian, Mississippian, Devonian, and into the Arbuckle of the Ordovician, a depth of a little over 3300 ft. A test of the Arbuckle gave fresh water.

The Salina basin covers about 35,000 sq miles. It has unconformities and porosity wedges, and a sedimentary section averaging 3000 ft which produces oil in nearby areas. Some fifty dry holes have been drilled to date, but they cannot be considered to condemn the area. G. D. H.

816. Two areas claim special attention P. C. Ingalls. *Oil Gas J.*, 31.8.50, **49** (17), 111.—Two Eocene Wilcox discoveries have been made in Concordia Parish, east-central Louisiana. One gave nearly 200 b.d. from 5976 to 5986 ft, and the other is to be tested at 6330 ft. The Wilcox is believed to have good possibilities in the Mississippi salt basin and in a belt between the Gulf coast salt domes and the Sabine uplift. It is the most important producer on the La Salle Arch, where Urania and Olla are outstanding.

The Glenmora Wilcox discovery at 10,700 ft is probably over a deep-seated salt dome.

In the Forest City basin the Viola and Lansing–Kansas City have shown oil 5 miles north and east of Davis Ranch. 3 miles north of the Strahm field the Hunton at 2826 to 2829 ft has shown oil in a drillstem test. Strahm has one Hunton and one Viola well. Davis Ranch is the only significant pool in the Kansas portion of the Forest City basin. It has eighteen producers. G. D. H.

817. Gulf opens new sand. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-74.—A new pay has been found in the Lake Misere field, Cameron Parish, Louisiana. 1-H Miami flowed 38 b.d. of 44·6° oil and 2,415,000 cu. ft. gas/day from 9947 to 9956 ft. C. A. F.

818. Michigan gas well flows from Berea. Anon. *Petrol. Engr*, Dec. 1950, **22** (13), B-74.—1 Gritzner Estate, Muskegon County, Michigan, flowed 4,100,000 cu. ft. gas/day from a Berea sand at 1125 ft. C. A. F.

819. Successes in Adams County, Mississippi. Anon. *Oil Gas J.*, 20.7.50, **49** (11), 131.—The Ellisle field was discovered in 1949 on a gravity and seismic feature. Production of 150 b.d. was obtained from lenticular Wilcox sand in the discovery well. Further drilling in 1949 gave three more producers and five dry holes. 1½ miles to the north the Sibley field has been opened by a 6406 to 6410-ft Wilcox producer. A second Wilcox producer was completed 1½ miles north-west of Ellisle, while a third 1950 well has pumped 37·8 b.d. from 10,300 to 10,320 ft. The Glen Aubin field was opened by a Wilcox well 5 miles northwest of Ellisle. The North Natchez field was opened by a 10,000-ft gas-condensate producer in the Lower Tuscaloosa, while the Kingston discovery well was a Wilcox producer at 6654 to 6656 ft. G. D. H.

820. Sholem Alechem is active again. P. C. Ingalls. *Oil Gas J.*, 10.8.50, 49 (14), 77.—Sholem Alechem, Carter, and Stephens counties, Oklahoma, was opened with Deese production in 1923. More than 5,000,000 brl of oil came from Hoxbar and Deese sand lenses at 1850 to 4200 ft in 1927. Production declined until the later part of 1947, when Springer production was found which raised the number of oil wells from 425 to 650. Production then rose in two years from 1915 to 16,000 b.d.

The field is now 10 miles long and 2 miles wide. Before the Springer discovery the cumulative production was about 44,000,000 brl, and in mid-1950 it was 57,500,000 brl, with remaining reserves estimated at 60,000,000 brl. There is a sharp anticline which rises some 1200 ft above the level of edge-water in important sands. The Springer reservoir has two main gas-cap areas. Springer wells averaging 5000 ft in depth cost about $75,000, although extensive coring and testing may add $25,000 more. Most wells are put on the pump on completion. Some wells have been shot, and the Hydrafrac process has also been used.

The field is on a major anticline near the axis of the Anadarko–Ardmore geosyncline. The fold is of late Pennsylvanian age, and has steep dips. G. D. H.

821. Rich pool found in " condemned " area. P. C. Ingalls. *Oil Gas J.*, 10.8.50, **49** (14), 119.—Gulf Oil Corp. 1 Wilson well in Cleveland County, Oklahoma, has been completed for 988 b.d. on a ¾-inch choke from the Trenton dolomite through perforations at 6072 ft and 6109 to 6119 ft. It lies in a section with three previous non-commercial wells. After the first two failures seismic work was carried out and the third well fitted closely into the geophysical picture. 1 Wilson found the second Wilcox zone watered. It may not be crestal. Only 1 ft of Bois d'Arc occurred in this well, pointing to truncation. The Bois d'Arc has oil possibilities. G. D. H.

822. Golden trend Deese pools spreading. P. C. Ingalls. *Oil Gas J.*, 27.7.50, **49** (12), 363.—Southwest Antioch was opened several years ago in the third Deese sand when drilling for structural accumulations in the Simpson. Further development in Garvin and McClain counties, Oklahoma, has established the up-dip limit of the third and fourth Deese sands which feather out as a shore-line against the truncated rocks of the Pauls Valley uplift. The productive belt is 25 miles long and up to 5 miles wide. Widening is going on towards the outlying patches of Deese production of Southeast Erin Springs and North Foster, and there is a spread towards Southwest Wayne.

The water level is fairly well defined in the third Deese sand, but it has not been found in the fourth Deese sand. In both cases the sands are lenticular with irregular productivity, but where known the fluid levels are remarkably consistent. In this Deese oil area at Katie the Layton also produces, in the northern part there are some Viola wells, at southwest Maysville a well has found Arbuckle production, and the Hunton produces at southwest Wayne. G. D. H.

823. 35 rigs drilling in Ringwood field. J. A. Kornfeld. *Oil Gas J.*, 14.9.50, **49** (19), 84.—The Ringwood field of Major County, Oklahoma, may cover 30,000 acres. On 40-acre spacing some 750 wells will be needed. There are ninety-five producers on 3800 acres. The field was discovered in 1945, by a well completed in the truncated Manning zone. Major development began in 1949. There are two Manning reservoirs

at depths of about 6700 to 7100 ft, and also the Meramec of the Mississippian, some 260 ft deeper. The Pennsylvanian has had shows.

Ringwood is on the northeast flank of the Anadarko basin on a south-plunging terrace, in association with a stratigraphic trap. Early Pennsylvanian erosion truncated the Manning. The surface beds are Permian, and total some 3900 ft, with 2700 ft of Pennsylvanian below. In the southwest the Manning is 177 ft thick, and consists of two limestone zones. The average porosity is 14%, and permeability 10 mD, while there is 22% of interstitial water. The oil gravity is 42°, and the bottom-hole pressure 2428 ft. Large volumes of acid have been used to treat both zones. The Manning is believed to be under solution-gas drive, with no original gas cap. Manning wells are up to 150 b.d. initially, and decline rapidly, requiring pumping after a few months.

Maps, logs, and tabulated data are included. G. D. H.

824. Expanding Ringwood. P. C. Ingalls. *Oil Gas J.*, 28.9.50, **49** (21), 52.—Ringwood has 115 Manning producers and thirty-five wells drilling. The field is not yet fully defined, particularly in the south and west. There are as yet no Lower Manning completions. Gas and oil shows have been noted in the upper Layton, Oswego, Prue, and Hunton. G. D. H.

825. Oklahoma field has new producing zone. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-74.—2 Hill, in the West Norfolk field, Payne County, flowed 60 brl oil in 15 hr from the Cleveland at 2553 to 2557 ft. The Peru was topped at 2798 ft. C. A. F.

826. Northwestern Oklahoma activity. P. C. Ingalls. *Oil Gas J.*, 28.9.50, **49** (21), 126.—Ringwood is expected ultimately to cover 50 to 60 sq. miles.

In Ellis County 1 Hanan is at 13,000 ft, and lower than expected, while 1 D. L. Berry has reached 9500 ft without having found more than slight oil and gas shows. 1 Harrison–Selman, a Mississippian test in Harper County, has been abandoned.

Northwestern Oklahoma is on the Northern Basin Shelf. There is evidence of early folding, and facies changes may also provide traps. In the past, efforts in this area have been held up by the inability to make reliable surface-structure maps, due to the nature of the surface rocks, and to difficult drilling conditions. G. D. H.

827. Oil in Oregon. P. de Armond. *Oil Gas J.*, 14.9.50, **49** (19), 67.—1 Fisher in south central Oregon, 9½ miles southwest of Lakeview, is reported to have had encouraging shows, and a production test was to be made. Three previous wildcats in Columbia, Washington, and Multnomah counties have been dry. G. D. H.

828. Coast opener successful. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-76.—1 Hughes Miller League, on the Texas Gulf coast, flowed 200 b.d. of 36° oil from 9365 to 9369 ft. Tubing pressure was 1230 p.s.i. C. A. F.

829. Kent County. R. F. Carlson and C. F. Hoot. *Oil Gas J.*, 3.8.50, **49** (13), 27.—The discovery well of Salt Creek in Kent County, Texas, tested 2184 b.d. from the Canyon reef at 6484 to 6520 ft. Offsets were good producers, and 2 miles to the south 2 L.T. Lohman gave 547 b.d.

Between Salt Creek and Cogdell 1 Spires produced 400 b.d. from the Strawn. Northwest of the Cogdell field two small San Andres producers have been drilled.

A map shows the sites of the various fields and wells, and Kent County dry wildcats are listed. G. D. H.

830. Simpson strike in North Texas. Anon. *Oil Gas J.*, 13.7.40, **49** (10), 127.—A well 5 miles west of Richardon Caddo field in southwest Montague County, Texas, seems to have opened a Simpson pool. Prior to the discovery of Viola production earlier in 1950 practically all oil production in North Texas was from the Pennsylvanian. A series of D.S.T.s have been made from 5981 to 6500 ft, and all have recovered some oil, the deepest flowing oil.

4 miles northwest of Bowie I.P.E. Boedecker was completed in the Viola in May, at 6800 to 6825 ft. It flowed 145 b.d. of 43·9° oil through a ¼-inch choke with a G.O.R. of 1375 p.s.i. A test of probable Lower Pennsylvanian conglomerate at 6121 to 6123 ft gave gas-cut mud. G. D. H.

831. Terry county is not another "Scurry." P. C. Ingalls. *Oil Gas J.*, 21.9.50, **49** (20), 389.—Reef production has been found at several points along the arcuate trend in Terry County, Texas. There is evidence of active water drive. There are signs that areas with ideal conditions for reef build-up are associated with Ellenburger structures. Reefs occur in the Canyon, as in Scurry County, and also in the Cisco and lower Permian–Wolfcamp. The reef at Wellman is in the Wolfcamp at −6435 ft, and has at least 100 ft of oil. It is lithologically like the Scurry Canyon. Between Adair and Wellman 1 Willard found the reef 1200 ft low, apparently because a saddle exists between two reef pinnacles. G. D. H.

832. Dozen rigs now running in Tex Harvey field. R. H. Carlson. *Oil Gas J.*, 13.7.50, **46** (10), 97.—Tex Harvey in Midland County, West Texas, has fourteen wells, and may ultimately have 500. Production is from two porous zones in the 1000-ft-thick Spraberry sand. The upper 300 ft has production from sand layers alternating with shale. Below is shale, and then a further productive zone. In all there may be 250 ft of sand. The main feed of oil may be via fractures, and shooting is beneficial. Cores show an average porosity of about 15% and a permeability of 0·2 mD. Recoverable oil is estimated as 97 brl/acre-ft by gas expansion, or 279 brl/acre-ft if there is an effective water-drive. Bottom-hole pressures of 2700 p.s.i. have been reported, and temp of 150 to 165° F. The oil gravity is 37° A.P.I., and initial potentials after shooting are 136 to 456 b.d. The pay is hard to drill. Loss of circulation occurs in the upper San Andres or Grayburg formation. There may also be losses in the producing zone.

Wells cost about $95,000. Commonly a liner is set at 7000 ft.

The pay section is thought to be an old shore-line, and the field is similar to Benedum, some 40 miles to the south in its relation to the edge of the Midland basin. Seismic work indicates some closure in the top of the Spraberry, but so far drilling has not revealed any reversal of dip. Fractures of 10 ft or more have been noted in cores.

G. D. H.

833. Fort Chadbourne field scene of active drilling programme in West Texas. R. F. Carlson. *Oil Gas J.*, 3.8.50, **49** (13), 48.—Fort Chadbourne produces from the Odon limestone (Strawn) in an area indicated as being 7 miles long and 3 miles wide. Oil occurs at 5300 ft, and the effective reservoir thickness is about 22 ft, with porosity of 12% and permeability averaging 100 mD. The original pressure was 2330 p.s.i., with a G.O.R. of 1034, and oil visc 0·31 c.p. at 134° F. Production is believed to be by dissolved gas drive. 40-acre spacing is used, and recovery is expected to be 2500 to 3000 brl/acre. Potential tests on four wells gave outputs of 132 to 336 b.d.

Allowables are fixed by 75% on acreage and 25% on the well. The field is expected to cover 10,000 acres. Trapping is by thinning and porosity pinch-out on a westerly dipping monocline. A gas cap is believed to occur in the east, while there is an oil/water contact at −3484 ft.

A map, section, and electric logs are given. G. D. H.

834. Stratigraphic trap search need shown by Wyoming basin. H. C. Rea. *World Oil*, Nov, 1950, **131** (6), 75.—Discoveries in the Powder River basin, Wyoming, in recent years have emphasized the need for a study of stratigraphical conditions within the Cretaceous in this area. All known surface anticlines on the periphery of the Basin have been drilled.

The Mush Creek, Fiddler Creek, and Skull Creek fields are stratigraphical traps, although they were long believed to be structural accumulations. The Taylor–Sussex field in Johnson County and the Glenrock field are also stratigraphical traps, where stratigraphy and pay porosity control the accumulations. In the Big Muddy field flank accumulation is controlled by the lenticularity of the Dakota sand. Oil is produced from a syncline in the old West Salt Creek field, where pay is Cretaceous sand and shale.

Structural conditions in the deeper parts of the Basin are unknown. A number of geophysical surveys have been made. C. A. F.

835. Mexican oil industry aided by new discoveries. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-76.—Four new oil areas have been discovered recently in Mexico. These are an extension to the El Plan field in Vera Cruz, a wildcat discovery in Tancoco, Vera

Cruz, a new pay in the Monterey field, and a potential producer near Tuxpam in Vera Cruz.

A group of new producing areas may be found along a line parallel to the Golden Lane in the Tancoco area. C. A. F.

836. Mexican venture starts. D. M. Duff. *Oil Gas J.*, 3.8.50, **49** (13), 32.—Drilling is to be first on the Trevino and Lomitas structures, with later work at Nogales and Santo Domingo. All are in the Frio–Vicksburg trend near Texas.

In southern Mexico Tortuguero 1, east of Puerto Mexico, is being deepened to test lower sands. It is directionally drilled. The initial output of 150 to 200 b.d. has now been sanded up. Tortuguero 2 is rated at 300 b.d., but is closed in until gas can be shut off. Xicalango 1 in Campeche showed gas at 7500 p.s.i. G. D. H.

837. New oil production discovered in Chile. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-68.—Oil has been discovered in the Cerro Sombrero area, 10 miles southeast of the Cerro Manantiales field. A well is reported to have flowed approx 300 b.d. of 39/42° oil. It is planned to connect the new field to the line joining Cerro Manantiales and the terminal at Caleta Clarencia. C. A. F.

838. Natural gas discovery made in Canadian area. Anon. *Petrol. Engr*, Jan. 1951, **23** (1), B-76.—Shultz-Royal 1, 30 miles northwest of the Viking–Kinsella gas field, Alberta, on a test of the Lower Cretaceous, flowed 2,820,000 cu. ft. gas/day from 2232 to 2247 ft. A test over the interval 2575 to 2595 ft gave 360 cu. ft/day. C. A. F.

839. Canada's Viking sand gets recognition. P. C. Ingalls. *Oil Gas J.*, 24.8.50, **49** (16), 203.—Joseph Lake is the first Canadian Viking sand oil pool. 95 miles to the southeast a second Viking pool has been opened, and what seems to be a third discovery is being completed 70 miles northwest of Joseph Lake. Drillstem tests at North Woodbend and Excelsior have recently had Viking oil shows.

The Viking sand and its equivalent or near-equivalents are present over most of Alberta and the southern part of Saskatchewan. It has given gas in the foot-hills belt, in the Sweetgrass Arch area, and to the east of Viking, etc.

Joseph Lake has twelve producers of 28° oil on an irregular anticlinal nose of slight relief on the regional monocline at depths of 3300 ft. Permeability and porosity range up to 4000 mD and 25%, respectively, while variable water levels indicate lenticularity. An 18-ft oil column is known. A strong water drive is expected. Proved reserves are estimated at 7,500,000 brl, but if drilling agrees with the seismic picture there should be favourable structural conditions to the south. G. D. H.

840. Systematic development programme followed by Canadian Gulf Oil Co. in Alberta's Stettler oil field. P. C. Ingalls. *Oil Gas J.*, 20.7.50, **49** (11), 70.—The Stettler field is on a seismic anomaly which was checked by core-drilling after 1 Jerard had found slight oil stains in the D.2 zone. Subsequently, 4 N. J. Ellis, 1½ miles to the northwest, found the D.2 higher, and with 50 ft of oil saturation. A D.S.T. at 5184 to 5234 ft flowed over 1,000 b.d. of 29·3° oil. The D.3 zone, tested at 5333 to 5379 ft, gave 1122 b.d. Eight offsets to the Ellis well have averaged over 1000 b.d. on test. The Madison is present, and the Banff, Exshaw, and anhydrite and salt of the Potlatch.

Producing G.O.R.s. are equal to solution G.O.R.s In April the offtake was 600 b.d. from seven wells. Jackknife derricks are used, operated on butane or diesel fuel. Generally no mud problems arise above the D.1 zone. The normally gas-bearing Viking sand horizon has shaled out. Controlled gypsum contamination is applied before entering the Potlatch. No appreciable mud losses occur in the D.2 zone, but there is always some loss in the D.3. One well in 160 acres is diamond cored. Wells take about forty days to complete. One well has been dually completed.

A cross-section, map, stratigraphic column, and electric and gamma-ray logs are included. In addition, diagrams show the dual-completion arrangements.

G. D. H.

841. El Mene deep test. Anon. *Oil Gas J.*, 3.8.50, **49** (13), 33.—A deep well at El Mene, northeast of Lake Maracaibo, has had oil and gas shows at 8550 to 8580 ft,

8686 to 8698 ft, 8878 to 8894 ft, and at 8930 to 8961 ft. Mechanical difficulties held up drilling at 10,451 ft, but the well is being taken down to the original Cretaceous objective. G. D. H.

842. First Jutland well fails. Anon. *Oil Gas J.*, 7.9.50, **49** (18), 52.—1 Frederikshavn in northern Jutland was abandoned at 4319 ft. Renewed work on 1 Gassum in central Jutland is planned; this was suspended at 9955 ft. G. D. H.

843. Europe: first offshore drilling. Anon. *Oil Gas J.*, 20.7.60, **49** (11), 60.—A well is being drilled 1½ miles offshore at Oxstedt-Spieka, southwest of Cuxhaven, Germany.

Eldingen 1, about 11 miles northeast of Celle is producing 113 b.d. from 5200 ft. This is associated with a faulted anticline. Quakerbrueck 6 is giving about 280 b.d. from 1900 ft. G. D. H.

844. French field grows. Anon. *Oil Gas J.*, 3.8.50, **49** (13), 34.—The Lacq field is reported to have given about 1900 b.d. Lacq is in the foreland of the Pyrenees, 24 km west of Pau, on a dome outlined by seismograph. Production is from an Upper Cretaceous limestone at about 2000 ft. Three wells have been completed. G. D. H.

845. Sicilian venture. Anon. *Oil Gas J.*, 7.9.50, **49** (18), 51.—An American company has obtained a concession of 100,000 hectares in southeastern Sicily between Ragusa and Siracusa. The area has heavy oil in near-surface sands and indications of gentle structure. A thirty-year term is specified, while royalty is on a sliding scale from 7% to 12%, dependent on oil output. Geological work and an airborne magnetometer survey have been executed, while some core-drilling, a deep well, and further surface work are planned. G. D. H.

846. Turkey's petroleum progress. R. L. Simons. *World Petrol.*, Dec. 1950, **21** (13), 43.—From 1935 to 1939 a dozen wells were drilled in Turkey, and in 1939 attention was directed to the Ramandag district in the extreme southeast. Five of the first tests had to be abandoned before reaching the objective, but ten others have been completed, three of which have since been abandoned because of water incursion. The best yield was 850 b.d., which was the limit of the pump capacity; others give about 500 b.d.

Two deep wells are being drilled near Adana.

A 100-b.d. refinery has been built at Batman, and a larger one is planned. In 1949 Turkey imported 447,000 tons of oil. G. D. H.

847. Aramco spuds first offshore test. H. Ozanne. *World Oil*, 1.2.51, **132** (2), 216.—A well is being drilled in the Persian Gulf, 20 miles south of Ras el Mishaab, 3 miles offshore in 20 ft of water. An offshore structure was indicated by gravity and seismic work. Offshore structure holes have been drilled to 1200 ft from barges, and one of these flowed oil from the Safamiya. C. A. F.

848. Oil possibilities in South Africa. Anon. *Petrol. Times*, 26.1.51 (1395), 63–4.—A number of wells have been drilled in the South African Union, but only traces of oil have been found. The deepest well was drilled at Dubbeldevlei in the Carnarvon district and was abandoned at 5080 ft in 1922. Most wells have been drilled where there are surface indications of oil, usually found as a distillation product associated with dolerite.

Exploration has shown that there are five areas in the Union in which there are oil indications and favourable structural and sedimentary conditions. These are: the Eastern Free State, northwest Natal, the Great Karroo, and the coastal belt of Zululand and the Sundays River Basin.

From 1944 to 1946 eight deep wells were drilled by the state survey, seven in the Cape Province, and one in the Orange Free State. Results indicate that no large oil accumulations can be expected in these areas. C. A. F.

849. Philippines look to increased oil activity. D. Andres. *World Oil*, 1.2.51, **132** (2), 220.—Increased oil activity in the Philippines is expected as a result of a petroleum law in 1949 which favours foreign operators.

Extensive state surveys prior to the second world war recognized three oil-bearing

horizons which are found in the Dutch East Indies. Favourable structures were also located.

Under the new law exploitation concessions are granted for a max of ten years, and exploitation concessions for twenty years, renewable for a similar period. C. A. F.

850. Shell seeks oil under the sea. Anon. *Petrol. Engr*, Nov. 1950, **22** (12), B-78.—Exploration is in progress off the South China Sea coast near Seria, where there is a field yielding 3 million tons/year. In the jungle swamps of Brunei off the Island of Borneo, where submarine drilling is in progress, 800-ft jetties and submarine loading lines have been constructed. C. A. F.

Geophysics and Geochemical Prospecting

851. Radio aids to oil exploration. C. Powell. *Petroleum*, Dec. 1949, **12** (12), 305–10.—A modification of the Decca Navigator radio system used for navigational aid is described, which extends the advantage of non-visual position-finding to ground reconnaissance work. There are three basic elements in the system: a chain of three or four transmitters set up at known points on the earth's surface, a radio receiver, and a special map or chart. The observer's position is given by two indicator dials on the receiver. A description of equipment and technique is given, using a practical field test as an example. Accuracy of fixes and errors are discussed. Practical examples are also given of the performance of the system as an aid to air-survey and hydrography.

The fact that the working ranges are independant of the heights above ground of the aerials, coupled with the simplicity and small size of the receiver, enables the system to be used effectively in vehicles and by ground parties. There is no question of substituting radio techniques for classical high-grade terrestial surveying methods, but radio techniques can now largely replace visual observations in reconnaissance work with a great reduction in time. From examples given it is possible to assess the applicability of the system to any position-finding problem encountered in oil exploration. R. E. P.

852. Radiowave prospecting for structure. R. Mann and E. Schmidt. *World Oil*, Nov. 1950, **131** (6), 92.—A broadcast radio beam, transmitted through the ground, is affected by variations in subsurface conditions. Experiments have been carried out on this technique as a means of prospecting. Several different circuits have been devised, some of which have been successful. It is necessary to measure accurately the intensity of a radio beam at any location, and to record automatically the interruption or increase or decrease in the broadcast signals.

The technique should be useful in conjunction with other geophysical methods. C. A. F.

853. Benefits derived from cooperative well surveys. J. Daly. *World Oil*, Nov. 1950, **131** (6), 81.—Velocity changes within subsurface formations can obscure or distort seismic observations, and in order to relate the seismic data to subsurface geological data, it is necessary to make well-velocity surveys. These are relatively expensive, and in general are made by individual companies. Recommendations are made for surveying on a co-operative basis by groups. C. A. F.

854. A two-level aeromagnetic profile across western Texas. H. W. Hoylman. *World Oil*, 1.2.51, **132** (2), 62–4.—By surveying with the airborne magnetometer at different levels it is possible to determine the average depth to basement beneath the survey level, and to separate the magnetic anomaly of an extrusive from the basement complex. A single two-level survey across western Texas is described. The method is economical and fairly accurate. C. A. F.

855. Geology and geophysics of the North Snyder area, Scurry County, Texas. N. Clayton. *Geophysics*, Jan. 1951, **16** (1), 1–13.—Most reefs in West Texas have been discovered by using indirect seismic methods, that is, the mapping of beds affected by the reef. At North Snyder the reef was directly located from reflections from the top of the reef.

The geophysical history of the discovery of the Snyder reef is described. Gravity,

magnetic, and seismic surveys have been made in the area. A gravity survey indicated a prominent max at North Snyder, and a magnetic survey showed no anomaly at North Snyder, but there was an east–west trend from an anomaly 3 to 4 miles to the east. As a result of seismic work, using normal reflection shooting methods, with 1000 to 1500-ft spaced holes, a pre-Permian structure was inferred and the discovery well was brought in in 1948.

North–south and east–west electric log cross-sections and contour maps of the field are included. There appears to be little sedimentary draping above the Pennsylvanian shale which compensates for the reef mass.

Gravity and magnetic maps and time cross-sections are included. C. A. F.

856. Patent. J. E. Hawkins, assr to Seismograph Service Corpn. U.S.P. 2,513,314, 4.7.50. Geophysical prospecting system (see also Patent No. 2,513,319, 4.7.50).

C. F. S.

Drilling

857. 2329 rotary rigs operating in U.S., Western Canada. N. Williams. *Oil Gas J.*, 27.7.50, **49** (12), 177.—On July 1 2329 rotary rigs were operating in the U.S.A. and Western Canada. Early in June West Texas–New Mexico had 768 rigs. On July 1 the figures were Gulf Coast 522, West Texas–New Mexico 730, Oklahoma–Kansas 448, Pacific Coast 131, Rocky Mountains–Western Canada 193, Arkansas–North Louisiana–East Texas 152. G. D. H.

858. First rig equipped with dynamic couplings being used on deep test. K. M. Fagin. *Petrol. Engr*, Nov. 1950, **22** (12), B-29.—Three electromagnetic eddy-current couplings have been installed on a three-engine, six-speed, air-controlled rig. The couplings will transmit 550 h.p. at 1000 r.p.m.

The couplings will not transmit torque at idling speed (400 r.p.m.) or lower. If the load is too heavy for the speed excessive slip will occur, but the engines will not stall.

Individual rheostats control the couplings. A master control switch enables all engines to be controlled as one.

Extremely flexible operation is possible with these couplings. C. G. W.

859. Drilling rig belt drives. T. G. Hicks. *World Oil*, Jan. 1950, **130** (1) 99–102.—Tables and examples show method of selecting correct V-belts for different types of drive. A. H.

860. World oil graphics. Anon. *World Oil*, July 1950, **131** (1) 101.—This inaugurates a series of cartoon drawings portraying abuses of rig equipment. Two or three half-page cartoons illustrate careless handling of such equipment as rotary hoses, wire ropes, etc. A. H.

861. World's most powerful barge-mounted rig. L. S. McCaslin, Jr. *Oil Gas J.*, 30.11.50, **49** (30), 66.—A rebuilt rig now capable of delivering 2680 h.p. to the draw-works is now drilling in Lake Washington, South Louisiana. Major new items of equipment are a mud mixer, fresh-water system, two main mud pumps, and electrical control equipment.

In the electric brake on the draw-works an amplidyne system is used to vary the field excitation in preference to the conventional fan-point control. Major equipment items are listed. C. G. W.

862. A model design of a new type drilling barge. F. Briggs. *World Oil*, Feb. 1950, **130** (2), 108–12.—Offshore drilling presents financial problems. The use of a pier as a drilling platform represents a capital outlay of at least $1 million. A floating or movable rig should therefore prove economical. A model of such a structure is described. Hinged platforms on either side hold pontoons. These platforms are raised to an appropriate angle to give stability when floating. When in position the structure is flooded, the pontoons are flooded, and the hinged platforms lowered to rest on the ocean floor, thus providing additional foundations during drilling. In sea depths of 40 ft the drilling platform is still 28 ft above the normal sea-level. A. H.

863. Marine platforms for offshore drilling. C. A. Trexel. *Oil Gas J.*, 7.12.50, **49** (31) 76.—One of the principal factors in the expense of offshore operations is the cost of the marine drilling platform. For shallow-water operations mobile, self-propelled drilling barges may be used, and recently, mobile drill barges for use in deep water have been developed. Such barges are proposed for exploration work, being replaced by permanent structures if oil is found.

One proposal for mobile barges is to support the barge on caissons. The caissons have enlarged bases, the soil loading being kept low by regulating the buoyancy of the caissons.

The barge is designed for drilling in water depths of 12 to 80 ft but can be modified for depths up to 120 ft. For water depths from 60 to 100 ft the dia of the bases should be 25 ft, the height of the base depending on the depth of the silt cover and other factors. The caisson dia vary from 48 to 60 inch, the steel thickness varying from $\frac{3}{4}$ to 1 inch.

A large-dia pipe through the centre of the caisson may be used to remove unsuitable foundation material from under the caisson base and also to place gravel, and a plug of concrete water pipes and air pipes are also run down the column.

For water depths up to 100 ft no underwater bracing is provided except for a stunt near the bottom in the caisson pier-braced frame.

The required soil-bearing values are not to exceed 1 ton/sq. ft. for all vertical loads and not to exceed 2 tons/sq. ft. including vertical components from wind, wave, and earthquake forces.

In order to reduce on-site construction time the caisson piers are assembled as two-pier or three-pier braced-frame bents which are transported by barge and erected on the site. The manner in which the bents are transported and assembled is described. Water and compressed air are used to flush soft material away during settling of the caissons. After the bases are firmly seated, a cavity under the base is filled with rammed gravel and a concrete plug. C. G. W.

864. Hurricane damage to drilling platform. R. C. Farley and J. S. Leonard. *World Oil*, Mar. 1950, **130** (4), 85–92.—This paper details the damage suffered by the Ohio Oil tests offshore drilling platform during the hurricane of Oct. 3, 1949. Before erection of a drilling platform it is necessary to have some knowledge of the ocean-floor contours, as these affect wave " pile up " and thus determine the safe height at which platform should be built. It is believed that the Stanolind Oil and Gas Co. platform avoided much serious damage by being built some 7 ft higher than the Ohio platform. Had adequate recording instrumentation been installed on the platform, invaluable data for the design of future installations would have been obtained. A. H.

865. Wave and storm factors in offshore structure damage. Anon. *World Oil*, Feb. 1950, **130** (2), 91–4.—A preliminary report on oceanographic and meteorological factors involved in damage to offshore structures (Ohio-Melben and Stanolind Oil & Gas Co) during the hurricane of Oct. 3–4, 1949, prepared by Amer. Inst. of Aerological Research.

From the large amount of data available it was possible to compute wave characteristics. Although the Stanolind rig lay directly in the path of the max winds, the waves at the Ohio-Melben were greater. It is concluded that a few waves broke over the Ohio-Melben platform producing a max horizontal dynamic pressure of at least 940 p.s.i. It is believed that these forces were chiefly responsible for the damage, although aerodynamic forces might also have contributed. A. H.

866. Adjustable ramp solves wildcat access problems. E. Sterrett. *World Oil*, Dec. 1949, **129** (8), 94–6.—A proposed wildcat location in the Atchafalaya Basin was subject to annual variations in water level of 17 ft, with the ground level being below water for as much as nine months out of the year. Expense of dredging approach canals ruled out the use of drilling barges. Being in a flood area, an earthen fill was not allowed. The access problem was overcome by the use of adjustable ramps leading down to the water's edge. A canal 5000 ft long was cleared between the two ramps. The channel was navigated by two barges towed by a steel tug boat hauled to and assembled on the site. Had any other type of approach been utilized the cost would have been higher. A. H.

867. Operators foresee new all-time drilling record. J. C. Casper. *Oil Gas J.*, 27.7.50, **49** (12), 170.—U.S. operators expected to drill 4391 wildcats and 18,435 development wells in the second half of 1950; in the first half 3837 wildcats and 16,421 development wells were completed.

Tables given the numbers of wells drilled in the first half of 1950 and expected to be drilled in the second half by states and districts, with breakdown according to type, and also the footage. G. D. H.

868. Drilling by the turbine method. C. Parsons. *World Oil*, July 1949, **129** (3), 87.—This introduction to the use of turbine drilling also gives a detailed description of the procedure in a particular case; at an input rated capacity of 900 g.p.m., the 9¼-inch O.D. turbo-drill may deliver 300 h.p. at 450 r.p.m.

The interchangeability of the turbo- and of the rotary drilling procedures makes for wider application, the type being used depending on the nature of the formation. It has been demonstrated that a faster and straighter hole with more regular hole dia may be easily obtained, even with crews who are relatively untrained in the use of turbo-drills. Even if the drill pipe is rotated slowly, 10 to 15 r.p.m., to prevent sticking, the wear on the pipe is much reduced.

The installation of a bottom-hole weight indicator is important, since the variation in load is confined to the drill shaft. The increase in working-bit speed is accompanied by a decrease in bit load, and a lowering of the neutral point in the drill string. Rig wear is much reduced in view of the reduction in vibration.

Advantages and disadvantages of the system are summarized. A. J. H.

869. The Bassinger rotary percussion drill. R. Brown. *Petrol. Engr*, Dec. 1950, **22** (13), B-42.—Early patents for rotary percussion equipment for rock drilling are briefly described.

In the Bassinger drill the bit is carried on the lower end of an anvil, and the hammer is returned after the power stroke, by a spring. The drill differs from early drills in that the hammer is permitted to overtravel on its return stroke until fluid pressure is sufficient to overcome the inertia of the hammer and the force of the return springs. The hammer is then accelerated on its power stroke by the fluid pressure reaching its max velocity as the piston leaves the sleeve and immediately before the hammer strikes the anvil.

In the latest development of this drill a ram spring has been added and the hammer piston replaced by a valve and seat.

In operation, the control sleeve, initially in its uppermost position with its top resting against the ram spring, is forced down by fluid pressure, carrying the hammer with it. When the sleeve reaches its stop in the guide the hammer continues down, opening the valve and exhausting the drilling fluid. The control sleeve returns to uppermost position against the ram spring. The hammer rebounds from the anvil seating in the control sleeve, overtravel being taken up in compression of the ram spring.

Increased fluid passage and decreased resistance have been provided by including a central opening through the hammer and spring mandrel. By these modifications the strokes per min have been increased from 225 to about 800.

The principal operating difficulties have been rig vibration, caving shale, and tapered hole. Means of overcoming these difficulties are under investigation. They are not sufficiently serious to outweigh the advantages of percussion drilling in many formations. C. G. W.

870. Rotary percussion drilling. R. Bassinger. *Oil Gas J.*, 12.10.50, **49** (23), 111.—The methods of applying a percussive action as well as a rotary action for drilling wells are described. In the Bassinger drill the drilling fluid is used to drive a hammer against an anvil carrying the bit on its lower end. Much work remains to be done before the tool can be used extensively. Principal problems involve the correct power per blow, frequency of blows, type of bit, amount of preloading, rotary speed, and pump pressure.

The solution of these problems is discussed. C. G. W.

871. New drilling methods and equipment. E. C. Hellums. *World Oil*, 15.2.50, **130** (3), 88–92. (*From the proceedings of Jan.* 31 *mtng, Houston Chapter, A.P.I.*).—New

methods and equipment described and illustrated include: Jet coring bits and the addition of guide ribs to coring bits. Charged pump suctions driven from main pump sheaves and designed to hold 15 p.s.i. at slowest speed.

The Bettis coil-type water-tube boiler designed to produce 20,000 lb steam per hr at max 500 p.s.i. and up to 500° F. Unit includes boiler-feed pump, burner, controls, heat exchanger, and steam separator permanently piped and mounted on one skid. Weighs 18,500 lb, is 8 ft × 15 ft 2 inches × 8 ft high without stack. Preliminary field tests show efficiency of 75–82%.

An air-powdered drill-pipe spinner. Abrasive material on a spiral spring grips the pipe to make the spin.

A rotary or propeller-type mud mixer.

Travelling block deflector (see Abs. No. 874). A. H.

872. The fluoroscope as a drilling aid. A. H. Messersmith. *World Oil*, Jan. 1950, **130** (1), 95–6.—The simple, transportable fluoroscope described has been designed especially for examining samples on the rig. A. H.

873. Applications of hydraulic drives to oil field equipment. N. A. D'Arcy. *World Oil*, Dec. 1949, **129** (9) 106–12, 119. (*Condensed from a paper presented before convention of A.A.O.D.C., Dallas, Sept.* 1949.)—The use of hydraulic couplings, hydraulic torque convertors, and combinations of the two are discussed, and performance characteristics given. Successful applications have been made on all sizes of drilling rigs, slush pumps, high-pressure cementing pumps, etc. On the rig, less maintenance is required, since the hydraulic drives absorb the shock loads. They also allow engines to be operated at their max efficiency regardless of the load conditions. Torque convertors are very effective on slush pumps, but care must be taken to select the proper ratio between convertor and pump. With proper ratios it would be possible, for example to use a pump either at 60 stroke p.m. and 450 p.s.i. or 30 s.p.m. with a pressure of 900 p.s.i. Performance charts of various sized slush pumps are given. A. H.

874. Humble's block deflector speeds trip time. J. E. Kastrop. *World Oil*, Jan. 1950, **130** (1), 83–5.—Humble Oil and Refining Co. have developed a block deflector which, used in conjunction with additional means to handle a single stand of pipe, is estimated to save 15 sec or more per stand when going in or coming out of the well. Parts required: a 6-inch steel I-beam monorail extending from first girt up to crown block; a carriage; a pneumatic power cyl, and adjustable steel cable. Twin cables threaded through pulleys on carriage to pulleys on block and back through pulleys on carriage deflect block as tension is applied by power cyl. A. H.

875. New penetration curve. J. A. Kornfeld. *Oil Gas J.*, 28.9.50, **49** (21), 102.—Actual drilling time is plotted *vs* depth. The depths at which new bits are run are shown. Portions of the bore hole penetrated by bits of the same size are shown in solid, others by dashed lines. Top and base of formations and type of formation are marked.

The chart may be applied: (1) to choose bits to increase penetration rates for particular formations; (2) comparison of relative performance of two or more rigs; (3) comparison of diamond coring and rock-bit drilling, etc. C. G. W.

876. Pumping application of fluid coupling. A. Gibbon. *World Oil*, Dec. 1949, **129** (9), 174–5.—A new type of hydraulic drive for pumping wells is described. A two-fluid media, oil and air, is used to allow variation of slip from 100% to a min of 2 or 3% or to allow the drive to be used as a disengaging clutch. A. H.

877. Allowable loads on an unsupported casing column. J. A. Reed and H. H. Meredith, Jr. *Oil Gas J.*, 19.10.50, **49** (24), 80.—Present practices in offshore well completions result in casing and tubing being suspended at the platform with lateral support at some point above the main water level. The next point of lateral support is below the ocean floor, generally 20 ft or so below the mud line. Consequently, there may be 100 ft or more of casing and tubing with no lateral support. The normal casing loads plus the action of tides, wave forces, etc., may exceed the ultimate strength of the column.

A method of determining permissible well-head loadings on offshore location is presented. The method is illustrated by an example.

The casing column is considered as a continuous beam with statically indeterminate stresses. The reaction at the lateral support, moment distribution, and deflection diagrams are obtained by graphical means. Equations are then developed to determine the allowable axial load on the casing head.

Two equations are derived, based respectively on column formulæ and on min joint strength. These are plotted as allowable casing-head load *vs* mean gulf depth.

In this computation wave forces were calculated by Munk's solitary wave theory and the airy wave theory, whichever gave the higher value of force at any elevation. The effect of storm tides on effective water depth is assumed to be 10 ft at all sites and that 40-ft breaking waves occur in water depths greater than 40 ft.

A new theory indicates greater wave forces than predicted by Munk, but this is not yet substantiated. References are appended. C. G. W.

878. Fatigue testing and development of drill pipe to tool point connexions. W. S. Bachmann. *Oil Gas J.*, 19.10.50, **49**, (24) 109.—A principal cause of failure in drill pipes has been at the cast point of engagement between tool joint and drill pipe. Failure at this point is generally due to bending fatigue. The last thread acts as a notch-and-stress concentration point, whilst the mass of the tool joint tends to set up transverse vibrations.

Laboratory fatigue testing to study drill-pipe tool-joint failures is described. Principal factors affecting fatigue failures are surface condition, notches, changes in section and clamping stresses, corrosion, and the size effect.

For a satisfactory tool-joint connexion it is desirable for the product of fatigue-failure stress and section modulus to be higher at the tool joint than in the pipe. Upsets should be as small as possible, wall thickness being increased slightly if at all.

The results of tests on various types of tool-joint connexions are briefly described and tabulated. C. G. W.

879. Wall collapse in oil wells as result of rock stresses. A. D. Topping. *World Oil*, July 1949, **129** (3), 112.—Wall collapse encountered in particular in deep wells is due to the disturbance of rock stresses. In this mathematical treatment of the subject the assumption is made that the rock is an elastic medium, and pressure distribution in the well is compared with that which would be obtained in a thick-walled hollow cyl of large dia.

Consideration of the ultimate rock stresses would suggest that failure is due to tension or to shear. It is unlikely that well collapse occurs under a static head of fluid, but possibly when the bit is withdrawn.

Six graphs illustrate certain aspects of the theory. References. A. J. H.

880. What do you know about surface casing failures? B. B. Smith. *Oil Gas J.*, 26.10.50, **49** (25), 78.—Causes and presentation of surface failures are presented in the form of a question and answer.

Recommended practices are to ensure good conditions of all equipment and get rig accurately lined up, run centralizers on caving, use float and guide shoe with a float value off bottom. It is advised that the cement plug be drilled out with a rock bit and that the drill pipe be protected by rubber protectors on each joint. C. G. W.

881. What do you know about drill collar failures? S. C. Moore. *Oil Gas J.*, 26.10.50, **49** (25), 79.—Causes and prevention of drill-collar failure are outlined in the form of a question and answer. Principal cause of failure is fatigue, frequently accelerated by corrosion.

Recommended practices are: (1) avoid excessive rotary speeds, (2) avoid extremes of torque, (3) use largest drill collars possible, (4) in cases of corrosion take active steps to avoid corrosion, (5) carry out preventive maintenance such as grinding out. C. G. W.

882. Automatic control for constant bit weight. J. N. Poore. *World Oil*, Dec. 1949, **129** (9), 87–92.—To obtain the most efficient drilling rate it is highly desirable for the bit weight to remain constant. No matter how diligent the driller, his method of manually feeding off the line from the draw-works drum by releasing his mechanical

brake will inherently introduce irregular application of weight on the bit. In the automatic control there are four main parts: (1) a regulated D.C. generator with automatically controlled output; (2) a D.C. motor which is operated as a " drag " generator, directly coupled to a speed reducer; (3) a main control panel; (4) a driller's small control panel. The " drag " generator maintains a constant restraining torque on the draw-works drum. Thus a constant weight is allowed to rest on the bit. Slight adjustments are made as additional pipe is added. As the rate of feed-off begins to exceed 1·5 f.p.m. an amplidyne exciter on the regulated generator acts to send more current through the armature of the " drag " generator, thus increasing the restraining torque. If the feed rate reaches 2·5 f.p.m. an overspeed trip device opens the main power circuit and sets a solenoid brake on the drag-generator shaft. An important feature of this automatic drilling control is its application to any type of rig whether it be mechanical, electric, or steam. A. H.

883. Non-destructive testing of drill pipe. N. Bowers. *World Oil*, July 1950, **131** (1), 87–92.—From the technical programme of the Production Engineering Conference, Pittsburgh, May 1949. The following methods of testing are briefly described and discussed: electromagnetic induction; magnetic field; penetrating radiation; mechanical vibration; mechanical caliper; luminous energy; electric current conduction; electric field; thermal; pressure, leak, and penetrant. A. H.

884. Lubricated plug valves for drilling and wellhead services. E. E. Hedene. *Petrol. Engr*, Dec. 1950, **22** (13), B-59.—The requirements of valves for oilfield flow lines are as follows: (1) standard dimensions; (2) standard materials except for unusual working conditions; (3) simple compact rugged construction; (4) reliable operation under adverse conditions; (5) adequate safety factors for working and test pressures. Shock loads, piping stresses, etc.; (6) positive shut-off. A small leak may lead to rapid cutting out of the valve; (7) long life expectation.

When designing lubricated plug valves for oilfield service, certain other conditions must be satisfied in addition to the above. Important among these are: (1) Rigidity, since the operation of this type of valve depends on the maintenance of an accurate tapered fit between plug and body, deflections must be kept to a min. Consequently, design is based on deflections rather than stresses. (2) Provision for lubrication. A lubricating system will consist of the application of plastic lubricant at flow system, lubricant-distributing grooves, and a fully enclosed chamber surrounding the small end of the plug. Applied lubricant will then momentarily unseat the plug. (3) An applied thrust to maintain the plug seating. Such a thrust must be accurately controlled, must not cause excessive resistance to turning, and must have a certain amount of resilience. Such a thrust is best achieved by a threaded thrust screw, the thrust being transferred, by a button, spring disc, and hard steel ball, to the plug. (4) Lubricants for this service are different from those for general industrial service. The use of compressible lubricants has made simple automatic lubrication possible. (5) Corrosive fluids can, when the expense is justified, be dealt with by the use of suitable alloy steels. (6) When dealing with abrasive or corrosive fluids as with excessive well pressures, hard-faced plugs and bodies have proved satisfactory.

Other factors to be taken into consideration are the layout of the lubrication system to avoid loss of lubricant during manipulation, and the coupling of the valve stem and the valve plug. In valves for small pressures the plug and stem may be made integral, but for higher pressures it is advisable to carry the thrusts separately and couple them for rotation only.

Some typical designs of lubricated plug valves are illustrated and described.

C. G. W.

885. Replaceable end drill collars in multiple collar strings. Part 2. Conclusion. B. E. Curran. *World Oil*, Jan. 1950, **130** (1), 104–8.—A section chart for semi-permanent connexions for collars of varying outside dia and bores, and a taper-joint selection chart are given. The theory of shoulder wear and thread failure is discussed, and the field tests carried out on this type of equipment are described. Twelve of this type of collar were used in an eighteen collar string to drill more than 32,000 ft in eight different wells. Seven failures occurred in the tapered joint connexions of the bucked-on replaceable end subs, but these were removed and replaced on the rig without difficulty. A. H.

886. Do's and don'ts in cable tool coring. E. A. Guenter. *World Oil*, Dec. 1949, **129** (8), 98–9.—Hints on cable-tool coring include the following: A 44-ft stem may be used with a standard rig. When using a spudder a much shorter stem will be necessary. Wherever possible a wire line should be used. The wrist pin should be set back to the second hole on four hole cranks and to the third hole on five-hole cranks. From 28 to 34 strokes/min is about the right motion for best results. Welding the drill head to the core band results in less fishing jobs. A. H.

887. Care and handling of cable tool wire lines. E. L. Klingler. *World Oil*, Feb. 1950, **130** (2), 96–8.—Several things can happen to a wire line during installation and service which may interfere with its ability to operate at top efficiency. Some of these conditions are within the power of the operator to alleviate. If a line wears out uniformly it can be considered to have given good service. Non-uniform wear usually occurs in one of the following forms: (1) Doglegs—usually due to bending during installation; (2) kinks—caused by a loop being thrown in line and drawn; (3) spiral wear—due to line being pulled around an obstruction such as a sill or small snatch block; (4) high strands—occurs in cable-tool lines; (5) corrosion which stiffens time.

A higher min safety factor in wells over 6000 ft can be obtained by using tapered line. A. H.

888. Vibration problems in drill pipe. K. N. Mills. *World Oil*, Feb. 1950, **130** (2), 83–6.—The problem of drill-pipe behaviour is of prime importance to the operator of a drilling rig, because it can have a definite effect on drilling costs. If the drill pipe is not kept in tension with sufficient collars, that portion which is in compression will tend to buckle, inducing bending stresses into the drill pipe. The pipe may also vibrate longitudinally or horizontally. The most probable vibration is that in the horizontal plane (or " whip ") due to operating at a critical speed. The critical speed of drill pipe in air and not subject to axial loads is :—

$$C_R = \frac{32{,}600n^2}{L^2}\sqrt{D^2 + d^2}$$

Drilling mud inside the pipe will increase the inertia of the pipe and will reduce the critical speed by the ratio

$$R = \sqrt{\frac{P}{P + O}}$$

The reduction in critical speed caused by compression is

$$M = \sqrt{L - \frac{SL^2}{EI\pi^2n^2}}$$

Similarly, the increase caused by tension is

$$M = \sqrt{L = \frac{SL^2}{EI\pi^2n^2}}$$

If pipe lengths corresponding to the span between two or more tools are considered, the equation of the fundamental ($n = 1$) can be applied to this reduced length. It is shown that lengths of 1, 2, or 3 joints are the only lengths worthy of consideration.

Graphs are given showing the load on drill pipes at various depths; the frequency *vs* length of drill pipe; the critical speed of various sized pipes; tensile load *vs* critical speed for various lengths of 4½ inch O.D., 16·6-lb pipe with 10 lb per gal mud; and frequency reduction with mud weight.

C_R = crit. speed R.P.M.
L = length (ft)
D = O.D. pipe (in)
d = I.D. pipe (in)
n = 1, 2, 3
R = a multiplier
P = wt. pipe/in length
O = wt. mud lb/in length
M = multiple.
S = axial load (lb)
l = length pipe (in)
I = moment inertia

A, H.

889. Improved techniques reduce well pulling costs. G. M. Wilson. *World Oil*, Mar. 1950, **130** (4), 168–9.—The crews of one producing company using conventional truck-mounted unit have saved time and work by : (1) breaking out rods with the box down instead of up. Windborne dust and debris does not accumulate in box. Also said to ease wrenching. (2) Standing rods on the floor instead of hanging in derrick. Accomplished easily if care taken in racking. Clean rag or burlap should be spread on floor to keep out dirt. (3) More care in racking of tubing. Singles are racked with collars up, seven wide and five deep, on short strips of wood to protect threads and to drain.
A. H.

890. Squeeze cementing. A. W. Walter. *World Oil*, Sept. 1949, **129** (6), 87.—It was originally assumed that hydraulic breakdown of formations resulted in horizontal fracturing, but it was later recognized that vertical fractures may also be formed. This is supported in theory by the comparison with fractures developed in pipes ; these are normally longitudinal.

Some of the data of normal, abnormal, and overburden pressures, available from numerous squeeze operations are reviewed and, from the pressure *vs* time graphs, the predominant features of a squeeze cement operation are listed. Certain field-core tests are reported, from which the behaviour of the cement was investigated. Photographs of core specimens are reproduced.

Conclusions of the paper are clearly listed and references given. A. J. H.

891. Air entrainment during primary cement jobs. W. Grossman. *World Oil*, Jan. 1950, **130** (1), 110–11.—There has always been speculation as to the amount of entrained air during cementing. The problem is analysed mathematically, and it is shown that even with the critical amount of cement the entrained air is compressed to a small footage. With more or less than this amount of cement the compressed air will be much less. A. H.

892. Evolution and use of gypsum cement for oil wells. C. E. Clason. *World Oil*, Aug. 1949, **129** (5), 119.—Originally in the use of gypsum cement the main difficulty was prolonging its setting time. Now it may be treated to set in 1 hr, after a period of 30 to 60 min, thus allowing time for manipulation. This is the main advantage over Portland cement. Characteristic also of gypsum is its expansion on setting.

The application of gypsum in " tamping nitro-glycerine " operations is explained, with reference to practical requirements ; also plug-backs ; bridge plugs ; bottom-hole plugging ; wild wells ; split, perforated, or corroded pipe ; cementing surface casing with gypsum cement. A. J. H.

893. Critical pressures in oil well cementing. N. C. Wells. *Petrol. Engr*, Oct. 1950, **22** (11), B-86.—It is pointed out that in any squeeze-cementing job, if the wall of the oil sand is imperfectly sealed the producing formation may be fractured and plugged. Production may be irreparably impaired.

It is suggested that honeycomb fracturing may occur without producing a break in cement pump pressure. There is also evidence that breakdown pressures may be appreciably below calculated values.

In view of these facts considerable care should be exercised in applying squeeze pressures. In order to remain under the breakdown pressure the following relation is proposed :

$$(0{\cdot}80 \times \text{depth}) - \text{fluid column weight} = \text{max pump pressure}.$$

The value of max pressure should never be exceeded.

Suggestions are offered for modifying the factor 0·80 in cases where the formation structure or other information is available. C. G. W.

894. Relative economics of diamond coring and drilling. C. Deely. *World Oil*, May 1950, **130** (6), 83–6.—Congo and West African Bortz bits are discussed, and their different structure, cost etc., compared. Due to the closely controlled diamond market, the purchaser gets reliability and performance in direct ratio to what he buys. With diamond coring it is possible to take long cores per trip, thus reducing rig time and costs per ft, *e.g.*, $15·12 per ft as against $19·65 for wire-line core head. If rock-bit

footage is less than 25 ft it is probable that diamonds will reduce the drilling costs. Whipstocking is another use for diamonds. Eight examples tabulated show cost per ft and estimated net saving by use of diamond coring as compared to rock-bit drilling.
A. H.

895. Offshore exploration by core drilling. J. L. Chase. *World Oil*, Apr. 1950, **130** (5), 129–34.—In offshore coring, difficulty is experienced in passing through the sea floor. Author believes that rotary drilling and coring would best meet this problem. Due to tidal movement, effect of waves and surges, this is a more difficult and hazardous operation than on land. Until more experience has been obtained no standard methods can be laid down. As a result of considerable coring work at sea a technique is presented, with details of equipment and its erection and operation, suitable for rotary drilling or the use of hydraulic cable tools. Casing is jetted and spudded into the bottom sediment until a firm vertical fix is obtained. This is braced by anchor lines. The dia of casing will depend on the depth of water and assuming a top load of 4000 lb a table gives the min size casing required. A platform and 13½-ft tubular derrick is fixed to top of casing. A mud barge with circulating pump is anchored close and connected with hose. A ship (40 ft) with special stern boom is securely anchored close in and supplies stands of pipe, etc. Instead of a rotary table, air-operated rotary tongs, connected by hose to an air compressor on the ship are proposed. Coring may be done at any time by using any 10-ft core barrel with whatever kind of shoe the formation requires for cutting. Hydraulic cable-tool methods, types of circulating pumps, etc., required are described.
A. H.

896. Don't hose your hole because of slush pump failure. W. J. Redman. *Oil Gas J.*, 2.11.50, **49** (26), 84.—Failure of equipment at critical time may prove expensive and troublesome. Initial selection of equipment suitable for the job undertaken coupled with an adequate preventive maintenance programme will avoid such failures. In the choice of equipment the capacity must be sufficient for max anticipated duty, but oversize equipment should be avoided. Undersize equipment working under a constant overload will have a short life and require expensive maintenance.

A maintenance programme for slush pumps is as follows: (1) keep liner sizes within manufacturer's ratings; (2) set relief valve to suit liner size; (3) keep liner spacer set-screws tight; (4) outside dia of liner should fit fluid chamber; (5) properly install valves and seats—flexible sealing disks should be in good condition; (6) piston-rods should be smooth and centred properly; (7) piston-rod packing should be properly installed and adjusted; (8) maintain diaphragm packing in good condition and properly centre extension rods; (9) adjust power and crossheads, keep fluid piston bodies in good condition; (10) use good-quality clean oil, change frequently; (11) adjust bearings, replace when necessary; (12) check bolts for tightness regularly; (13) keep suction line short and direct, avoid air leaks and pockets; (14) use suction strainer, clean frequently—do not let sand accumulate in suction line or pump passages; (15) use strainer in discharge line and use full-size discharge line from pump to standpipe; (16) protect exposed parts when idle or stacked; (17) drain fluid ends when standing idle in cold weather.
C. G. W.

897. Application of mud pumps. K. N. Mills. *World Oil*, Aug. 1949, **129** (5), 106.—The functions of mud circulation include the removal of cuttings, the maintenance of an efficient drilling tool, and in soft formations, the acceleration of penetration.

The main consideration in the removal of cuttings is the slip velocity, which increases with size of particle, is higher for round than for flat particles, and decreases with increase of mud visc and density. Thus, to prevent the bit from "balling up," in particular in soft formations, the design of the bit should allow for high nozzle velocities. To prevent the drill pipe sticking, the slip velocity should not be such as to permit the accumulation of particles in the annulus. It is undesirable, however, to have excessively high annular velocities owing to the increased pressure required; a return velocity in the annulus of 175 to 200 f.p.m. is recommended by some operators.

In considering mud flow, pipe and annular conditions must be estimated independently.

The selection of mud pumps is considered in relation to the above factors, and the comparison made between steam- and power-driven pumps. Series pumping units for

the delivery of mud at high pressure for deeper drilling are finding wider application, but are more satisfactory when steam driven. The installation of accumulators intermediate between L.P. and H.P. pumps tends to even the load, and with power pumping, an accumulator on the discharge side does lengthen the life of the unit.

Ten graphs represent flow conditions, pump loading, and the fluctuation of discharge pressure. References. A. J. H.

898. Vacuum tank trucks move mud. C. Thompson. *Petrol. Engr*, Oct. 1950, **22** (11), B-45.—Tank trucks of 55 and 33 brl capacity are being used for rapid transport of drilling mud. A rotary positive-blower-type pump capacity 900 cu. ft. free air per min, with a vacuum of 20 to 22 inches of mercury enables the truck to be evacuated or pressurized. Such a tank truck can load 55 brl of fluid of density 10 to 17 lb/gal in about 9 min. Savings in time and mud are considerable. C. G. W.

899. Effect of oil emulsion mud on drilling. J. P. Weichert and O. W. Vandyke. *Petrol. Engr*, Nov. 1950, **22** (12), B-16.—The use of emulsion muds has resulted in increased drilling rates, bit life and time on bottom and decreased rotating torque, pipe drag, and circulating pressures.

Emulsion muds consist of a normal mud base with added crude oil, fuel oil, or diesel oil and an emulsifying agent. When made up the oil is dispersed throughout the mud as fire-drop bits. It is the lubricating properties of the dispersed oil to which the advantages of emulsions are largely attributed. The three principal properties of the emulsion muds are: (1) lubrication; (2) sealing of the well bore; (3) preferential wetting of steel surfaces.

Data obtained in field tests are presented in detail. In nearly all cases, and particularly with directional holes, improvements in drilling performance were obtained.

It is believed that important factors are: (1) reduced torque and friction gives more accurate bit weight readings; (2) oil wetting prevents falling and clogging of bit teeth; (3) oil wetting improves lubrication of bearings and reduces wear on teeth.

Sloughing of hole wall can also be corrected by use of emulsion muds. Field experience illustrating such points are described. C. G. W.

900. A study of the effect of NaCMC on bentonite. B. W. Brown. *World Oil*, Sept. 1949, **129** (6), 122.—The recent production of sodium carboxymethyl cellulose has made this compound commercially available for the treatment of muds. The addition of the chemical to a clay has the effect of increasing the desirable drilling characteristics, while restricting the increase to a function of the clay properties. The deductions are made from the tests carried out on four types of bentonitic clay. Four tables; references. A. J. H.

901. Top water control with plastic in the East Texas field. J. O. Crouch. *World Oil*, Sept. 1949, **129** (6), 116.—The use of plastics for setting liners and short strips of pipe was first introduced to the East Texas field on Jan. 2, 1944, as an alternative to the use of cement. Progress made in this field is reviewed with reference to the 113 operations, of which 102 were initially successful, and the principle of operation described. A setting time of 8 to 10 hr is recommended for the plastic around the liner, while excess plastic is removed by reverse circulation. The importance of formation logging is mentioned. A. J. H.

902. Case history of lost circulation jobs in the Leduc–Woodbend field, Alberta. H. F. Naldrett. *Canad. Min. metall. Bull.*, Oct. 1950 (462), 548–51.—192 wells had been completed by Imperial in the D_3 zone in the Leduc–Woodbend field at the end of May 1950. Of these, sixty-two lost circulation for varying periods during drilling. Independent operators completed fifty-nine wells in the D_3, of which nine lost circulation. Most known fillers have been used in attempts to overcome this problem. The most commonly used is sawdust, which is added to the mud before the D_3 zone is penetrated. Where circulation loss has been serious, small cement plugs in series have had to be used.

A map showing wells in the area which have lost circulation is included. C. A. F.

903. Well completion practices. Part 1. Completions. C. M. Beeson. *World Oil*, Nov. 1949, **129** (8), 87–92.—The underlying purposes of this series is to emphasize the

need of progress in the completion stage of the drilling and production of oil wells. The term " completion " has been defined so as to include all the operations that occur between penetration of the top of the producing horizon and commencement of settled production. In this first part some of the basic considerations such as coring, completion fluids, cementing techniques, etc., have been reviewed. A. H.

904. Well completion practices. Part 2. Muds. C. M. Beeson. *World Oil*, Dec. 1949, **129** (8), 114–19.—Fluids used during completion may be separated into two classifications: (1) completion muds; and (2) wash fluids. The various types of completion muds are further classified. In selecting a mud for a given zone, consideration should be given to the following factors: (1) ease of removal of mud from well bore; (2) ease of removal of filter cake; (3) penetration of mud into formation pores; (4) penetration of filtrate into zone; (5) hydration of clays present in formation; and (6) formation of precipitates by interaction of filtrate and interstitial water. Reference is made to laboratory methods of obtaining a measure of these factors. A. H.

905. Well completion practices. Part 3. Well washing. C. M. Beeson. *World Oil*, Jan. 1950, **130** (1), 88–90.—The various types of wash fluids and their development are described. They can be classified as follows: (1) Aqueous—fresh water, saline solutions, dispersants, acids; (2) non-aqueous—crude oil, refined oil, oil–water solvents. Drawings illustrate the action of suction and pressure washing tools. A. H.

906. Well completion practices. Part 4 (Conclusion). Remedial work. C. M. Beeson. *World Oil*, Feb. 1950, **130** (2), 104–6.—The methods of removing plugging materials are classified and discussed. Whenever possible laboratory tests under bottom-hole conditions are recommended, as these should provide the information necessary for selection of wash fluid or technique to be adopted. A. H.

907. Average completion cost is 20% of the total well cost. T. A. Huber, T. O. Allen, and G. F. Abendroth. *Oil Gas J.*, 16.11.50, **49** (28), 234.—It is estimated that the average completion cost is about 20% of the total well cost. Since the production of a well and subsequent remedial and workover jobs depend on a satisfactory completion, considerable attention is now being paid to ensure good completions.

From the first wells drilled it is necessary to form a reservoir evaluation that will provide information for later well-completion practices. Developments in the major phases of well completion are reviewed. Present trends are towards development of: (1) improved mixing of modified low-tensile cement and improved bond between formation cement and pipe; (2) improved bullet perforators and techniques for jet perforators; (3) improved placement fluids and technique.

Other factors are discussed. References are appended. C. G. W.

908. New method logs dip and strike of subsurface formations. Anon. *World Oil*, 1.2.51, **132** (2), 57.—A new logging technique has been devised whereby the dip and strike of subsurface beds can be measured.

Differential erosion of formations within the borehole causes the hard beds to project into the bore, and from measurements of the vertical displacements of the edges of these beds it is possible to calculate their angles of dip and strike.

Continuous records of the well profile are obtained in three azimuths at 120° spacing. Formations resistant to mud erosion appear as peaks on the curves, and " ledges " can be identified on the three profiles and their relative positions determined. The vertical scale of log is greatly enlarged compared with normal caliper logs, and it is possible to measure very small vertical displacements.

The subsurface equipment consists of a dip-indicator probe with two centralizers. The top section of the probe contains three spring-loaded profiling arms. Movement of the arms causes electrical changes, which are modified and recorded by surface equipment. The lower section of the probe contains an orientation unit.

A mechanical computer is used to facilitate the calculation of dip relative to the borehole. C. A. F.

909. Optimum use of coring electric logging and other testing methods in exploratory wells. J. E. Walstrom. *Oil Gas J.*, 16.11.50, **49** (28), 298.—The co-ordinated use of

logging techniques in exploratory drilling is reviewed. The principal available methods are: (1) coring; (2) formation testing; (3) sidewall sampling; (4) electric logging; (5) drilling fluids and cuttings analysis; (6) gamma-ray logging; (7) neutron logging; (8) induction logging; (9) micro-logging; (9) continuous electric logging at the bit. Desirable drilling fluid characteristics are outlined. As a result of an analysis of formation-evaluation methods, three exploratory drilling-programme charts are presented: (1) testing on way in; (2) testing on way out in open hole; (3) testing on way out inside casing.

In all three programmes: (1) electric log is always run; (2) interesting horizons on the electric log not evaluated by other means are sidewall sampled; (3) an interval is formation tested if cores or logs indicate possible oil or gas production.

Exploration programmes used in particular areas are described. Thirty-four references are appended. C. G. W.

910. Deepest pumped oil well. Anon. *Petrol. Engr*, Nov. 1940, **22** (12), B-77.—New 2, Pico Canyon, California, is reported to be the deepest pumped oil well. The bore pump is set at 11,614 ft, and it is operated through a tapered sucker-rod string. Production rate is 85 b.d. C. A. F.

911. Patent. R. P. Courtney, assr to Union Carbide and Carbon Chemical Corpn. U.S.P. 2,512,716, 27.6.50. Oil-well sealing compositions prepared from water, Portland and aluminous hydraulic cements, a water-soluble base-catalysed resin made from phenol and formaldehyde, and a free water-soluble lower aliphatic aldehyde. C. F. S.

Production

912. New production methods and equipment. Anon. *World Oil*, 15.2.50, **130** (3), 144–7.—(*From the proceedings of Jan.* 31 *ming of Houston Chapter, A.P.I.*).—New methods and equipment described included :—

Micro electric log utilizing electrical contacts with spacings of 1 and 2 inches, able to measure the resistivity of the mud cake built up on porous medium. Permeabilities percepted by this tool are in low range of 1 to 4 mD.

Method of hydraulically lifting a fishing tool with the load applied on the bottom of the hole instead of surface equipment.

The Johnston hydraulic rig utilizing the principle of hydraulically lifting the drill string with one line.

A simplified Purger Choke.

A combination bottom-hole choke and a bottom-hole separator.

A teleflood meter or bottom-hole flow meter. This is a vane-type water-meter actuating a hammer. The hammer taps on a steel rod which carries the impulse to the surface, where it is recorded. A. H.

913. Standard Oil Company of Texas' marine operations in Galveston Bay. J. E. Kastrop. *World Oil*, July 1949, **129** (3), 137.—The development of a marine submerged field presents difficulties which include safety precautions, for the prevention of pollution of water, weather conditions, and frequently also the competition of adjacent shore fields. Standard Oil of Texas and Salt Dome Oil Corp. brought in the first wildcat on Feb. 12, 1938, and much information has since been collected on marine drilling and production on practices.

Production from the three fields, Cedar Point, Smith Point, and East Red Fish Reef, terminate at a tank battery on shore at Cedar Point. Separate production lines are needed for the separation of clean oil from oil requiring treatment. Separators at the two larger fields of Cedar Point and Smith Point eliminate the need for individual well-production lines to the shore battery and also facilitate the testing of specific wells.

Safety precautions include the installation of a storm valve which closes flow when there is an excessive drop in pressure due to broken lines. A. J. H.

914. Unique hook-up for testing marine wells. J. E. Kastrop. *World Oil*, Aug. 1949, **129** (5), 145.—Saving in pipeline costs of marine located wells is effected by the installation of a central separator and single production line to the shore station. For

separate well testing, a large separator and stock tank were also installed at the central gathering centre. Special features include an unusual link-up of well lines, and an automatic cut-out device in operation during individual well testing; this is a precaution made necessary by weather conditions, and the possibility of isolation during storms. Pollution of waters has to be avoided.

The principle of operation of the safety valve, based on the differential pressure, is explained in detail. A. J. H.

915. Reservoir engineering in secondary recovery. D. T. May and T. C. Canan. *Producer's Monthly*, Apr. 1950, **14** (6), 14.—Difficulties encountered in the recovery of oil emphasizes the need for careful reservoir engineering study; such study should commence with the discovery of the field. In secondary-recovery projects problems of efficient production have to be considered in relation also to the application of energy to the reservoir. Historical data play an important part.

It is economically desirable to utilize old wells of the primary development; this, however, should not be the ultimate factor of control in the well lay-out. Thus, a wide well pattern may be ineffective owing to the loss of energy between injection and producing wells. A case of a Bradford property is selected as an example, which under natural production gave 1600 brl/acre, under haphazard flood, 3800 brl/acre, and under five-spot pattern flood, 6900 brl/acre. The importance of designing a well pattern is evident. A. J. H.

916. Secondary recovery evaluation. R. C. Earlougher. *World Oil*, Apr. 1950, **130** (5), 169–70.—The principal considerations in secondary recovery are enumerated and discussed. Development costs in the mid-continent area range between about $1400 per acre for 330 by 330-ft spacing at 500-ft depths to about $2500 per acre of 1320-ft spacing at 2900-ft depths. A. H.

917. The effect of gas on recovery when water flooding long cores. L. Schiffman and J. N. Breston. *Producer's Monthly*, Jan. 1950, **14** (3), 11.—The use of high gas concentration ahead of water flood may prove to be beneficial in secondary-recovery projects. The effects of such a system include the modification of the physical characteristics of the crude, temporary selective plugging effect of the gas, and the advantage of a minor gas drive. Tests on Bradford and Venango sands of permeability to brine of 2·55 mD. and 49·0 mD. showed increased recovery ranging from 7·7 to 13·5%, and 17 to 20%, respectively.

The explanation of the experimental procedure is accompanied by a diagram of the apparatus. The analysis of the results, which are tabulated and expressed graphically, is covered in detail.

Conclusions are discussed. A. J. H.

918. The mechanism of air-gas drive. D. E. Menzie and R. F. Neilsen. *World Oil*, **Part I.** June 1950, **130** (7), 212–26; **Part II. Conclusion.** July 1950, **131** (1), 147–60. (*Presented at 12th Ann. Conf. on Secondary Recovery, The Pennsylvania State College.*)—Throughout the oil industry there is a difference of opinion as to the effect of increased pressure gradients, during secondary-recovery processes, upon ultimate recovery of oil. Investigations, in the field and laboratory, of the residual oil saturation after a flood is reduced when using a high-pressure gradient, have not been in agreement. In these experiments change in pressure gradient during a series of air drives was studied. A sample of consolidated sandstone was used as reservoir rock. After extraction and drying a long core of the sandstone was mounted in lucite. Electrodes and pressure plugs were fixed through the lucite. It was saturated with 0·2N brine, and a series of air drives then run. The results are shown in several graphs. It was concluded by the authors that: (1) A fairly constant rate of recovery prior to break-through was observed for each driving pressure, with some increase immediately prior to break-through. (2) A greater brine production was indicated before break-through for the higher-pressure gradients. (3) Calculated values of saturation at break-through agree with observed saturations by resistivity. (4) Error introduced by neglecting $\left(\frac{\partial Pc}{\partial x}\right)$ in the fractional-flow equation is small up to break-through. (5) A method of calculating relative permeabilities to the liquid phase is presented. (6) Calculated end effect based

on capillary pressure phenomena showed agreement with measured end effects. (7) The curves of final residual brine saturation distribution for the various pressures appear to show the same residual saturation for any section of the core. (8) The capillary pressure curve shows an irreducible min saturation. (9) The pressure gradient during an air drive on a 100% saturated core does not affect the ultimate saturation. (10) The final residual brine saturation at any point is a function of the pressure during the air drive at that point, relative to the pressure at the producing end. A. H.

919. Gas lift operations and problems. C. V. Kirkpatrick. *Petrol. Engr*, Nov. 1950, **22** (12), B-17.—Recent developments in gas-lift equipment and procedures have made it an important operation in oil recovery.

Efficient operation of gas-lift installation depends upon an understanding of the mechanics of the control of gas injection. Although some wells can be satisfactorily produced by inserting an orifice in the tubing-string gas-lift valves are generally necessary.

Such valves may be automatic, depending upon a pressure differential between tubing and casing for their operation, or surface controlled. Surface-controlled valves may be pressure or wire-line controlled. The operating principles of and best operating conditions for various types of valve are outlined.

Mechanical difficulties associated with gas-lift operations have been largely overcome, but operating conditions create problems. The handling of sand emulsions, the presence of paraffin deposits and surface restrictions all raise difficulties in operation. Development of dual-completion gas-lift equipment and of combustion flow-valve and plunger-lift operation will considerably extend the applications to gas lift.

It is concluded that, where gas is available, the gas-lift valve if selected to suit well conditions, and where full reservoir information is used to design the installation, then gas lift has wide and economic applications in oil recovery. C. G. W.

920. Gas lifting oil in Turner Valley field. S. F. Shaw. *Petrol. Engr*, Oct. 1950, **22** (11), B-32.—This field is characterized by low porosity and low permeability. In such fields secondary-recovery methods are rarely successful, and it is important that initial recovery methods should be efficient.

Production in this field has indicated that where extraction has been restricted a gradual increase in gas–oil ratio results. It would appear that in this case extraction at low rates would increase the ultimate oil production.

Gas lift should be applied at the stage where the gas produced with the oil is no longer sufficient to lift the oil to the surface.

Tables are given of production and G.O.R. under conditions of natural flow, restricted flow, and under gas lift in the field. C. G. W.

921. Water-drive performance in oil sand from oil field data. H. M. Ryder. *Producer's Monthly*, Mar. 1950, **14** (5), 12; Apr. 1950, **14** (6), 32.—Discussion is based on data obtained from wells drilled over a period of six years to the Bradford Third Sand. The main objective was the study of the effects of high-pressure flood over such a period.

Sand samples were completely immersed in solvent to prevent the possible loss of crude fractions. To justify A.P.I. gravity readings, a volatile, saturated petroleum fraction was used as solvent; pentane was found to be the more suitable, since it may be removed from the extract with the least evaporation of the latter. Correction factors for evaporation losses were applied to tests on samples of less than 2 g. A degree of uncertainty in gravity determinations was met with oils of A.P.I. gravity greater than 40°, but since the greater part of this oil was encountered in the unflooded area, no particular significance was attached to this fact.

From the tests conducted in this area it was concluded that no appreciable decrease in oil saturation has been obtained by reflooding sands. The reduction in A.P.I. gravity of the oil in the sand is attributed to the solution of the light ends in the water flowing past the oil, and was more pronounced in the " open " sands. The oil in the previously unflooded sand was found to have a higher A.P.I. gravity than that in the previously flooded sand. For greater production from these sands, a high-velocity flood is recommended.

A summary of results is given. References. A. J. H.

922. Measuring oil reserves by injected gas. F. Squires. *World Oil*, Sept. 1949, **129** (6), 170.—It is assumed that, for volumetric reservoirs of moderate size with no gas cap, the time to reach equilibrium after injecting gas is small.

The theory of the calculation of the quantity of oil is explained. A. J. H.

923. Boiler generates inert gases for injection at Elk Basin. Anon. *World Oil*, Jan. 1950, **130** (1), 166.—A special boiler plant designed and built by Stanolind Oil & Gas Co. and twenty-nine other working interests generates 15 m.c.f. of inert combustion gases daily. The plant burns residue gases and generates about 52,000 lb steam/hr. A. H.

924. Larimore gas injection project. M. A. Remke. *World Oil*, May 1950, **130** (6), 164–6.—Reservoir performance, production history, and discussion of operation of the Larimore (North Central Texas) repressure project are given that production engineers may apply the same technique to similar fields. The Larimore sand pool (at approx 700 ft) is on a monocline dipping gently to the northwest with its longitudinal axis roughly parallel to the strike of the monocline. An Isopach map indicates its lenticular nature. Average permeability is 1000 mD. ranging from less than 1 to 4200 mD. Average porosity about 25%. Assuming the primary recovery to be correct, net oil recovery due to gas injection is estimated to be 21½% of the stock-tank oil-in-place. A. H.

925. Increased oil recovery from injection operation. R. L. Evans and R. P. Roe. *Oil Gas J.*, 28.9.50, **49** (21), 68.—It is pointed out that by normal primary production methods not more than 30% of the original oil can be recovered from a depletion-type reservoir. The necessity of unitized operations for the successful application of secondary-recovery methods is emphasised.

Examples of the application of gas and water injection are described, and the characteristics of depletion-type reservoirs with reference to the potentialities of injection practices are discussed.

Thirteen references are appended. C. G. W.

926. Gas lift, principles and practice. Part 1. C. D. Fletcher. *World Oil*, July 1950, **131** (1), 157-64.—General principles and controlling factors of gas-lift operations are discussed. Modern practice may be divided into two categories: Intermittent flow; Automatic differential and continuous flow. A table compares the effect of varying injection cycle and injection period. A. H.

927. Water flooding in Weber Pool. Part I. J. H. Johnston and J. A. West. *Oil Gas J.*, 7.12.50, **49** (31), 179.—The first of a series of condensations of a report on the development geology, production statistics, practices, reserve calculations, with descriptions of the operation and results of air and gas injection and water flooding. C. G. W.

928. Experts discuss water-flood problems. A. Gibbon. *World Oil*, June 1950, **130** (7), 235–40.—Usually sponsored by U.S. Bur. Mines, water-flood operators in Oklahoma and Kansas meet annually to discuss their problems. Proceedings of this year's meeting are reported on in question-and-answer style. Some sixteen questions and answers are given, *e.g.*, What is max content of connate water permissible in predicting a successful flood? Is there any experience of flooding limestone or dolomite reservoirs? A. H.

929. Patoka Benoist water flood. H. S. Barger. *Petrol. Engr*, Oct. 1950, **22** (11), B-72.—The Patoka field, Marion County, Illinois, was discovered in 1937. The discovery, 1 Meryman, flowed 100 b.d. of 39° oil from the Bethel sand (Benoist) at 1418 ft. Development was on an irregular pattern, and 132 producers were completed on 700 acres. Initial per well production was 40 to 150 b.d., and in 1938 a max field production of 2400 b.d. was reached, Production subsequently declined rapidly, and it was estimated that natural recovery would be equivalent to approx 15% of the pore space, or 225 brl/acre ft.

Following reservoir studies a pilot water flood was initiated in 1943, using nine

intake wells and four producers. This was successful and the flood area was expanded, development being completed in 1946, with fifty-nine intake wells and thirty-nine producers. Injection water comes from the Tar Springs sand at about 1000 ft. Salinity is about 100,000 p.p.m. Injection rate is about 10,800 b.d. Prior to flooding field production was approx 700 b.d. (1943), and this subsequently increased to a max of 4560 b.d. in 1946 and has now fallen to 800 b.d. Total cumulative oil production (natural and flood) as at Mar. 1950 was 8,251,000 brl. Ultimate recovery is estimated at 9,200,000 brl (650 brl/acre ft). Total development cost was about 1400 dollars/acre.

The geology of the field is briefly described, and contour maps and performance curves of the field are included. C. A. F.

930. Flooding prospects of Illinois basin oil sands. F. Squires and P. G. Luckhardt. *World Oil*, Mar. 1950, **130** (4), 146.—Flooding has been successful in the Siggins, Patoka, and Basin McGlosky fields in the Illinois basin, and further pools suitable for flooding are being sought among the 300 fields in the state. Studies in progress include water analyses, gas/oil and water/oil ratios, and the rate of edge-water encroachment. The Waltersburg has been flooded in the New Harmony field, the Tar Springs in the Maunie South field, the Bethel in the Patoka field, and the McClosky in several areas on the Nobel anticline. The Benton field is being prepared for flooding, and thirty-six fields have been selected for study.

Maps are included to show the oilfields in the Basin, with the positions of surface streams, areas of fresh-water sands, and locations of existing flooding operations. Principal characteristics of pays and photomicrographs of cores are included.

C. A. F.

931. Flooding increases unit output from 34 to 1600 barrels oil per day. J. F. Adkisson. *World Oil*, Nov. 1950, **131** (6), 177.—Water flooding in the Fankhauser field, Greenwood County, Kansas, is described. The field was discovered in 1926, and thirty-three producers had been completed by the end of 1927. Pay is Bartlesville sand at about 1900 ft. Water flooding under unit agreement commenced in 1949, when total field production had fallen to 34 b.d. As a result of secondary recovery production has been increased to about 1645 b.d. One well increased from 1½ b.d. to a max of 330 b.d.

Input wells are drilled on a five-spot pattern on 10-acre spacing. There are now twenty-two injection wells, four water supply, and twenty-five oil producers. Total input rate is 4000 b.d. under 300 p.s.i. Water-supply wells are completed in the Douglas sand at about 800 ft, which has a water composition similar to the Bartlesville interstitial water.

In the first sixteen months of water flooding the recovery was equivalent to approx 30% of the primary production.

Production equipment and control installations are described, and production curves of the field are included. C. A. F.

932. Telefloodmeter measures input water. O. L. Patterson, J. R. Vaughan, Jr., and Q. B. Marsh. *World Oil*, Aug. 1949, **129** (5), 148.—Description is given of the meter which operates on the impulse-turbine principle. The turbine shaft, acting through a reduction of 1000 to 1, winds a spring which is released at intervals by a cam, thereby actuating a hammer. Sound transmission of the hammer knock at the meter to a recording device at the surface enables the quantity of water flowing to be measured. Since the relation between counts and production is linear, a simple digit counter is sufficient to enable the production to be estimated. Alternatively, the graphical relationship between interval signals and flow rate may be used to estimate the production over a short period. Range of operation is from 2000 b.d., with four nozzles open, to 50 b.d., with only one open.

The chamber has an O.D. of 4⅝-inch and contains the mechanism in oil under pressure. Shaft friction is reduced by the labyrinth system of packing. Power consumption at surface is very small, but the necessity for smooth running is emphasized, as the impulse signal has to be transmitted over the length of tubing, or sucker rod. The importance of clean sucker-rod joints and other practical details are mentioned.

A. J. H.

933. Conditioning water for subsurface injection. G. G. Bernard. *Oil Gas J.*, 12.10.50, **49** (23), 101.—Specific water-treating problems and their solutions are presented.

1. Sequestration of iron. To prevent oxidation of ferrous iron 4 p.p.m. of Calgon was added, and sodium hypochlorite was added at the well head to eliminate bacteria.

2. Corrosive and super-saturated water treated by de-aeration, stabilization by sulphuric acid, sterilization by sodium hypochlorite, and filtration.

3. Hydrogen sulphide brine treated by aeration, flocculation with brine, chlorination filtration, and de-aeration.

Other problems dealt with are the effect of vacuum on the stability of $CaCO_3$, chlorination, corrosion, and incompatible brines. C. G. W.

934. Water conditioning for oil field flooding operations. N. A. Voss and E. Nordell. *Oil Gas J.*, 9.11.50, **49** (27), 174.—Waters for oilfield flooding must be: (1) non-clogging; (2) non-corrosive.

Waters for this purpose may be fresh waters, brines, or connate waters, and the properties of waters vary widely. Clogging may be due to inorganic or organic impurities, while corrosion is generally due to dissolved gases. Treatment of waters is designed to remove substances likely to clog or corrode. Water conditioning involves removal of: (1) turbidity sediment; (*a*) coagulation plus filtration, (*b*) sedimentation coagulation, settling, and filtration; (2) oil. Removed by gravity separation; (3) iron. Aeration at low pH plus settling and filtration—organic or colloidal iron removed by coagulation with aluminium sulphate; (4) CO_2—reduced by aeration (if high bicarbonate content the water should be stabilized by brine treatment); (5) hydrogen sulphide. (*a*) treatment with flue gas followed by aeration, (*b*) chlorination, (*c*) oxygen. Removed by de-aeration in vacuum de-aerator; (6) calcium carbonate. Removed by treatment with brine; (7) calcium sulphate—dilution to a value below the saturation concentration at the max expected temperature is sufficient; (8) organic impurities may be removed by chlorination. C. G. W.

935. Chemical treatment of flood waters used in secondary oil recovery V. P. Gregory, C. R. Groninger, and J. H. Prusick. *Producer's Monthly*, May 1950, **14** (7), 27.—A review is given of tests conducted on waters having properties ranging from mild acidity to alkalinity at pH of 10·5 to determine the relative effectiveness of certain organic compounds for treating flood waters. The tests included those for corrosion, interfacial tension, bactericidal properties, and adsorption on silica sands.

From the results, which are given in eight tables, it is recommended that a combination of three chemicals would be necessary for effective control; inorganic anti-oxidant, quaternary ammonium compound, and a wetting agent.

References. A. J. H.

936. Tubing repairs in water input wells. J. W. Ferry and J. C. Vaughn. *World Oil*, Sept. 1949, **129** (6), 166.—Significant loss of efficiency is caused by corrosion and by the development of small leaks in input well tubing; in the old Bradford, Penn., area, as many as 30 to 45% of wells have been found to be imperfect. The method described, although unorthodox, has proved successful, and consists of injecting a rubber plug held in a carrier down the input well. On reaching the leak, the increased water velocity creates the conditions suitable to seat the plug. This stage of the operation is noted at the surface by a sudden rise in pressure. The authors have been successful in fifty-four out of sixty-four operations. A. J. H.

937. The Cranfield cycling-pressure maintenance unit. Part I. Basis of the unitization agreement. L. E. Hines. *World Oil*, Feb. 1950, **130** (2), 131–46.—In an effort to unitize the Cranfield field, Basal Tuscaloosa, and Paluxy sands, three companies have managed to adopt methods where by resulting calculations, etc., established equity to the satisfaction of practically all. With the help of analysis and recovery calculations, isopach maps, graphs, etc., these methods are described. The effectiveness and productivity of the sands were determined from electric logs of each well penetrating the formation, cores, side-wall core tests, and drill-stem tests. Areas were measured by planimetering carefully 1 inch = 500 ft scale maps. Sand-pore interstitial-water percentage was estimated by a reliable core-service company. Material-recovery assumptions made for each field are discussed. A. H.

938. The Cranfield cycling-pressure maintenance unit. Part 2. General operational plant. L. E. Hines. *World Oil*, Mar. 1950, **130** (4), 139–44.—The design of the plant and field facilities each took into account an overall reservoir production rate which was consistent with the max reservoir efficient production rate and the economics of recovery. Two different type gases were allowed for. The gas-cap gas would be produced directly to the plant-inlet condensate separator. Black oil would be separated from formation gas in the field at 1700 p.s.i. The black oil would then be flashed to 500 p.s.i. and produced to the plant for further treatment. Gas–oil ratios at each well were to be measured regularly. Calculations showed that sufficient gas would be available from the Paluxy formation to maintain 100% pressure in Basal Tuscaloosa reservoir for at least four years. A. H.

939. The Cranfield cycling-pressure maintenance unit. Part 3 (conclusion). Gas well flow rates from electric models. L. E. Hines. *World Oil*, Apr. 1950, **130** (5), 174–87.—Initial individual gas-well production rates of the Cranfield Basal Tuscaloosa field were determined by electric model analyses. A description of this model is given, together with a full review of the theory of this determination. An isopotential map from the electric model and an isochron map of the field are given. A. H.

940. " On the beam " pumping. J. S. Fuller. *Petrol. Engr*, Dec. 1950, **22** (13), B-27.—It is recommended that studies and investigations involving the following equipment be made routine procedure :

1. An accurate polished-rod dynamometer complete with planimeter for determined well loads, h.p. requirements, counter-balance, etc.
2. A recording tachometer for quick determination of counter-balance condition, and for prime-mover studies.
3. Bottom-hole pressure- and temp-recording instruments.
4. A pH value instrument for identifying acid conditions and simple chemical tests for identifying gases.
5. Electrical potential indicating instruments to indicate stray currents.
6. Set of A.P.I. thread gauges.
7. Depthograph or echometer to be used for determining fluid levels, drawdowns, location of seating shoes, packers, etc.

In the selection of pumps for well pumping, having selected size and stroke length three principal problems have to be considered, namely : (1) abrasion ; (2) corrosion ; (3) impact. In selecting pump parts to resist abrasion, hardness is the first consideration. Hard materials, particularly cast materials, are more abrasion-resistant. When relatively softer materials are used, dissimilar materials generally give better wear. Boron-irons are extremely hard, and due to their low friction characteristics are good for pump parts. They should not be used in H_2S environments.

To avoid corrosion it is necessary to avoid using metals which set up excessive galvanic action. The use of alloy steels is of value, but in extreme cases of corrosion, inhibition, or some other form of protection is necessary.

Impact loading may cause breakage of pumps, particularly where the pumps are of cast materials or are of the sectional-liner type. Use of longer, slower strokes and avoidance of " pumped-off " conditions should reduce such breakages.

The selection of pumping units and sucker-rods for various conditions is also described. C. G. W.

941. Well counterbalance. L. G. Fenn. *World Oil*, Sept. 1949, **129** (6), 145.—Imperfectly balanced pumping units result in very greatly reduced efficiencies, due to excessive, and uneven, wear on power components.

There exist two main forms of counterbalance, the beam weight and rotary weight. Their relative advantages are considered by the author, and it is concluded that for slowly rotating pumps, the beam weight is more suitable, while the rotary weight is more adaptable to higher pumping speeds.

No particular type of counterbalance may be applied generally to a field ; a particular case is examined for the consideration of the more suitable balance system.
A. J. H.

942. Volumetric behaviour of oil and gas from a Louisiana field 1. H. H. Reamer and B. H. Sage. *Petrol. Tech.*, Sept. 1950, **2** (9), *A.I.M.M.E. Tech. Paper No.* 2950, 261–8.—Formation vol and the vol of the liquid phase for three mixtures of oil and gas have been measured for five different paired samples of oil and gas from a Louisiana field. Temperatures ranged 40° to 250° F, tank-oil gravities 38° to 55·5° A.P.I., and the G.O.R. were varied from 200 to more than 40,000 cu. ft/brl. The experimental data are presented in graphical and tabular form. G. D. H.

943. Abnormal pressures and lost circulation. P. E. Chaney. *World Oil*, Apr. 1950, **130** (5), 122–6. (*Substantially as presented at* 1949 *Mtng A.P.I. Divn of Production, Galveston.*)—A new theory to account for abnormal pressures in hydrocarbon and salt-water reservoirs in Gulf coast area is proposed, based on the assumptions that: (1) the zone is an isolated or sealed reservoir and (2) oil and gas are formed by progressive degradation and rearrangement of high-mol.-wt. organic materials. The degradation probably continues until all hydrocarbons have been reduced to the simplest and most stable molecules or until reservoir is tapped. An increase in fluid volume without increase in reservoir volume can only result in increased pressure, until this equals overburden pressure, when effective reservoir vol increases due to lifting of overburden or fracturing of shale bed. In confirmation hydrocarbon content of shale cuttings in areas of abnormal pressures is consistently several times higher than that for shales of same age near areas of normal pressure. Abnormal-pressure salt-water reservoirs, it is concluded, have been in contact with abnormal-pressure hydrocarbon reservoirs. Lost circulation accompanying abnormal pressures occurs when mud weight is approaching the weight of overburden and results from tensile failure of the sediments along lines of weakness. Cementing would seem to be the only corrective measure, and even with this the result is doubtful. The most promising approach to the problem of lost circulation is through careful control of all sources of pressure loading upon the bore hole and its reduction to a min consistent with safety. A. H.

944. Critical analysis of the effect of well density on recovery efficiency. W. O. Keller and F. H. Callaway. *Petrol. Tech.*, Sept. 1950, **2** (9), *A.I.M.M.E. Tech. Paper No.* 2938, 269–80.—An analysis of the problem reveals that there is no reason to expect an appreciable variation in recovery efficiency with well-spacing in terms of energy relations. Observed variations in actual recoveries with well density between different leases in the same field can be attributed largely to regional migration. Comparison of field-wide recoveries has not as yet furnished a positive answer to the well-spacing question, although this is a fundamentally sound approach.

Consideration of the principles of reservoir mechanics indicates that the variation in recovery efficiency with well density will be very small. The well-spacing problem in most fields can be resolved in terms of whether or not continuity exists, by means of properly planned and executed testing programmes. Existing data indicate that continuity exists in most fields.

The well-spacing problem has been of more concern in depletion-type reservoirs than in those with water-drive. In the latter the recovery efficiency depends on the average oil saturation at which limiting water–oil ratios can be expected, and a variation in recovery efficiency with well-spacing must be the result of reaching the limiting water–oil ratio at different average oil saturations with different well spacings. G. D. H.

945. The effect of pore size on oil recovery when flooding long unconsolidated sand cores. C. B. Dale, R. McFarlane, and R. V. Hughes. *Producer's Monthly*, May 1950, **14** (7), 8.—Previous work on oil recovery had dealt mainly with factors of the system, other than pore size. In this series of experiments, twenty-seven floods were conducted using four mesh size sands. After chemical treatment the sands were mechanically tamped, thereby ensuring a reproducibility of porosity to within 2%; porosities were in the range of 35 to 39%. The cores were mounted in Lucite and had a total length of 30 inches with 2½ inches I.D.

The effects of pore size were more marked in the range of pressure differential 0·5 to 1·0 p.s.i/ft. Up to water break-through, the behaviour of most sands was according to the same general pattern; the residual oil saturation for each core was 38% at break-through.

Results are summarized and references given. Eight graphs and five tables.

A. J. H.

946. Selective pressures release bypassed oil. F. R. Cozzens. *World Oil*, Feb. 1950, **130** (2), 159–61.—Economic completion of an air-drive oil-recovery venture is dependent to a great extent on the quantity of oil: (*a*) dislodged and (*b*) produced. With sufficient energy 80% of all movable oil can be dislodged, but its recovery depends not only on the strength, but also on the distribution of the energy. Continuous, intermittent, and directional pressuring are the most widely employed energizing tactics. On one input the pressure on a porous strata may be 50 p.s.i. less than the pressure against a tight or restricted area. This position is then reversed, and the pressure on the porous strata is made greater than that on the tight area. Similarly, selected producing wells are often shut off for periods of 36–40 hr. These and other practices discussed aim at manœuvring oil from tight or by-passed areas into zones of lower resistance, where it can be forced to the pumps with less effort and expense. A. H.

947. Injectivity indices—their prediction and determination. N. Van Wingen. *World Oil*, Feb. 1950, **130** (2), 152–6. (*Presented at secondary recovery symposium, A.P.I. Divn of Production, Oklahoma City.*)—Injectivity data on producing wells, when used in conjunction with other pertinent data, will give an early indication of plugging, etc. Radial or spherical flow formulæ can be used, but they are often cumbersome and tedious. In a number of projects it has been found useful to use a mass productivity index, *i.e.*, pounds of hydrocarbon material produced per pounds per sq. inch drawdown. If bottom-hole pressure at various injection rates cannot be measured, it will have to be computed. Experimental measurements of friction drop were lower than those computed by the Weymouth gas-flow equation, but higher than those computed by the Weisbach equation. Adjustment of the friction factor in the Weisbach equation gave better agreement. The adjusted friction factors have been plotted as a function of Reynolds number, and should be generally applicable to any string of 2½ inch tubing. By combining an expression for column weight with the Weisbach equation, an expression for bottom-hole pressure is derived. A. H.

948. The role of wettability in oil recovery. P. T. Kinney and R. F. Nielsen. *Producer's Monthly*, Jan. 1950, **14** (3), 29.—The extent to which certain fluids are present in the interstices of a porous medium is governed by the wettability of the solid by the liquid. These phenomena in rocks have been demonstrated by similar conditions in glass capillaries; a concave liquid surface is formed in the phase which preferentially wets the solid surface. Capillary behaviour is dependent, however, on which phase first wets the surface; thus relative permeability of a core is affected by its previous history.

Results obtained from core tests are discussed, with particular reference to initially oil- and water-wet sands. The percentage of recoverable oil produced before water break-through was found to be greater when flooding with water in a preferentially water-wet core than in a preferentially oil-wet core. In the particular case of Bradford cores, there was a tendency for the sand to be preferentially oil-wet.

Results are expressed graphically. References. A. J. H.

949. Measuring porosity of oil field cores. C. J. Rall and D. B. Taliaferro. *World Oil*, Mar. 1950, **130** (4), 157–64.—A condensation of *U.S. Bur. Mines Rep. Invest. No.* 4548 "A Bureau of Mines method for determining porosity: A list of porosities of oil sands."

Basically the method consists of determining the bulk volume of the sample by displacement of mercury in a stainless-steel pycnometer also the volume of void space in a bomb with sample by introducing compressed gas and measuring its pressure, reducing pressure to atmospheric and measuring gas vol accurately. The vol of sand grains is then found by diff. Full details of apparatus and method are given, and for normal work dry air is recommended. For more precise work helium or other gases are used. In addition R.I. 4548 contains details of specific vol of Hg and factors for deviation of air and helium from ideal gas laws. A. H.

950. Residual water and residual oil by capillary techniques. C. D. Stahl and R. F. Nielsen. *Producer's Monthly*, Jan. 1950, **14** (3), 19.—Capillary pressure tests were conducted on Bradford, Berea, and Venango sands. The cores were first saturated with brine. Displacement of the brine by oil was followed by flooding the complex by brine. Differences between the "irreducible minimum" water saturation and connate water saturation were attributed to phase discontinuity.

From the nature of the results, it was deduced that the Bradford and Berea Sands were definitely not water-wet, while the Venango Sand showed preferential wetting by water.

Experimental procedure is outlined.

Five graphs and references. A. J. H.

951. Low temperature separation increases recovery of condensate from natural gas. A. F. Barry and A. S. Parks. *World Oil*, June 1950, **130** (7), 202–10.—In gas lines water is necessary for hydrate formation. All natural gas is saturated with water under bottom-hole temp and pressure conditions. If enough of this can be removed no hydrate can form. Two methods exist: (1) first heat then reduce the pressure on the well-head gas, separate liquids, and contact the tail gas with a dessicant; (2) cool the gas at well-head pressure and remove liquid water, then reduce the pressure. For many purposes sufficient water is removed by method (2). Unitized packaged units are now available for this method. The effect on condensate recovery is discussed.

A. H.

952. Characteristics of reservoir models by resistivity logging. J. C. Cook. *Producer's Monthly*, Mar. 1950, **14** (5), 24.—The development of resistivity logging and its application to the determination of formation porosity and permeability would greatly facilitate, and reduce the cost of, reservoir surveying. The resistivity of a brine-invaded core is a measure of its effective porosity in the inter-connected channels. The deviation of porosity determinations, as calculated by Archie's formula, from " true " porosities was found to be approximately 10%.

The rate of invasion of the formation by fresh water was a measure of the permeability, and for the purpose of interpretation, the ratio of change of average resistivity during invasion, to average resistivity after invasion was found to be a function of the permeability. Determinations were claimed to be within 1% accuracy.

The model well consisted of a stack of $2\frac{1}{2}$-inches dia Bradford cores with a $\frac{1}{2}$-inch bore, representing the well. The individual characteristics of each core were clearly defined on the electric resistivity log.

References. A. J. H.

953. A study of reservoir performance of the First Grubb pool, San Miguelito field, Ventura County, California. W. E. Glenn. *Petrol. Tech.*, Sept., 1950, **2** (9), *A.I.M.M.E. Tech. Paper No.* 2951, 243–60.—The San Miguelito field is an asymmetrical anticline, 2 miles long and $\frac{3}{4}$ mile wide with a northwest–southeast trend. The west flank dips at 40°, and the east flank at 60–75°. The First Grubb pool comprises eight Lower Pico and Repetto siltstones and sandstones separated by shales. Forty-eight producers have been completed since the discovery of the pool in 1931. There is 685 ft of pay in 1220 ft of sandy section. The cumulative production is 15,600,000 brl from 276 acres. The weighted average porosity of 800 samples from twenty wells is 18%, while the average permeability is 86 mD. The extent of the productive sands increases with depth.

The original saturation pressure is estimated as 3000 p.s.i.g. at −5500 ft and 158° F. A formation volume factor of 1·428 was used. Reservoir oil viscosity was 0·92 cp, and the solution G.O.R. 890. Gravity drainage has been effective in maintaining a high oil saturation down flank, but the reservoir is primarily of the solution-gas-drive type. Gas injection was initiated in 1940.

In spite of heterogeneity of the sands, lamination, and faulting there is evidence of interference between wells. A number of early water-base mud wells had abnormally low productivity indices after an initial clean-up period, and in one case the index had improved by about 60% when the cumulative production was 126,000 brl.

Recoveries to date range from an average of 18 brl/acre/ft on the north flank to 136 brl/acre/ft on the south flank. Permeability is low on the north flank.

Diagrams and tables present data on reservoir performance. G. D. H.

954. Petroleum conservation in the Penn grade area. J. Boyd. *Petrol. Engr*, July 1950, **22** (8), A-36.—Research carried out by the U.S. Bureau of Mines in developing improved oil-production methods in the Appalachian area is outlined.

Field offices have been established at Franklin and Bradford in Pennsylvania, where

both fundamental and applied research are conducted. Oil operators assist in the work, and field projects can operate simultaneously with laboratory work.

Research in progress includes engineering studies of selected fields, electrical analogy flow studies of gas-injection and water-flooding projects, correlation of residual oil saturations with pore patterns of sand after laboratory air-drive tests, cable-tool coring, selective plugging of air/gas-injection wells, flowing of oil wells on gas-injection projects, well-shooting with explosives, and water-flooding studies. C. A. F.

955. Hendricks and Henderson—some operating problems in old limestone reef fields. K. M. Fagin. *Petrol. Engr*, Jan. 1951, **23** (1), B-62.—The Hendricks and Henderson fields, Winkler County, Texas, have been effectively flooded by a natural water drive, and some of the present operating problems are typical of other reef fields flooded by water.

The Hendricks field was discovered by T. G. Hendrick I in 1926. Wells completed in the field had initial potentials up to 4000 brl/hr, and in 1929 field potential was 2,655,787 b.d. from 468 wells, or an average of 5675 b.d/well. The structure is an anticlinal reef, approx 9 miles by 3 miles. Proved acreage is about 12,000. Pay is Permian Seven Rivers " white lime," averaging 300 ft in thickness, and there is some production from the " brown lime." Virgin bottom-hole pressure was about 1720 p.s.i. In 1928 many wells were producing 99% water, and in 1932 average water production was 98% for the whole field. Present water production is over 99%, and cumulative water production is over 11 billion brl. Over two-thirds of the wells have been abandoned.

The Henderson field was discovered in 1933, but was not developed until 1936. Wells were not as prolific as in the Hendricks field. The structure is a north–south-trending anticlinal reef with proved acreage of about 2800. Pay is Seven River limestone at about 3050 ft, averaging 100 ft in thickness. Virgin bottom-hole pressure was about 1450 p.s.i., which declined to 1282 p.s.i. in 1942, after 6 million brl water had been produced. Development was much slower than at Hendricks, and water production was not excessive until 1944. Present water production is 97 to 99%, and cumulative production is over 600 million brl. About half the wells have been abandoned.

A canal system has been built to remove the water from both fields, and some is evaporated in large pits. Severe damage by corrosion occurs in the Hendricks field below 2000 ft, but working level in most wells varies from 700 to 2000 ft. There is little corrosion trouble at Henderson. C. A. F.

956. Leduc D-2 zone pool. J. E. Baugh. *World Oil*, 1.2.51, **132** (2), 210.—Approx 175 wells have been completed in the D_2 zone (Nisku) in the Leduc field, Alberta. The pay is a blanket reef of dolomite, averaging 150 ft in thickness. It is overlain by red beds and underlain by green shale. Porosity is variable, from intergranular to cavernous. There is anhydrite filling of the pores at the crest of the structure where the pay is non-productive. Oil–water level is very variable, and thin local gas caps have been found near the centre of the field. No continuous gas cap is believed to exist.

Average wells have 25 to 30 ft of D_2 production, with a porosity of 9%. Permeability ranges from 0 to 100 mD., and connate water is 15%.

Virgin b.h.p. was 1760 p.s.ig. and solution G.O.R. 681 : 1. The productivity and pressure decline of wells varies considerably. Water drive is considered unlikely, and ultimate recovery, assuming only solution gas drive operates, is estimated at 20%.

General completion practice is described, and curves showing production performance of the D_2 zone, a cross-section of the field, and a table of reservoir data are included. C. A. F.

957. Reservoir performance in Leduc field. L. O. Roland. *Petrol. Engr*, Mar. 1950, **22** (3), B-69.—There is a slow pressure decline within the gas-capped D_2 zone in the Leduc field. During the nine months preceding December 1949, average decline was about 1·6 p.s.i. for all wells, and concurrent withdrawal was about 600,000 to 700,000 brl/month. The natural drive is believed to be combined gas cap and water.

Data on reservoir conditions within the D_2 is limited. Porosity and permeability are very irregular, and there are large pressure differences between wells.

G.O.R. are irregular in both zones, but ultimate primary recovery is expected to be greater in the D_3. There appears to be no gas cap or water drive in the D_2.

Current drilling activity in the field is generally limited to offset wells and extension tests round the fringe area. Recent wells indicate that there may be an important extension in the D_3 zone to the west of the central and northern sectors of the field.

C. A. F.

958. Down-hole chemical treatment to clean clogged formations. Anon. *World Oil*, Mar. 1950, **130** (4), 171.—The following chemicals are introduced into the shot hole in the order given :—Heats of solution and neutralization melt the paraffin, and the excess acid reacts with carbonate. A compressor maintains positive pressure on the well.

Strong solution of alkali-metal hydroxide, excess concentrated aqueous solution of a mineral acid with sulphurized quinoidine as inhibitor; inorganic carbonate in water (for greater penetration); a coating compound to form protective emulsive coating; excess mineral acid.

The method was evolved by V. D. Lawmaster, to whom has been granted a patent described as " relating to a method of treating oil and gas or disposal wells . . ."

A. H.

959. Some aspects of core analysis as it pertains to secondary recovery. R. Staples. *Producer's Monthly*, Apr. 1950, **14** (6), 16.—Representative data from cores is an essential to the successful planning of a secondary-recovery project. In selecting a suitable driving medium, consideration should be given to the oil saturation; thus a higher oil saturation is necessary for a gas drive than for a water drive.

Chief problems in core analysis are sampling and interpretation : incomplete core recovery may lead to erroneous conclusions. Permeability should be determined in both the vertical and horizontal directions. Selective shooting is adopted for the purpose of adjusting the permeability profile of the sand face.

The estimation of the value of a property on the basis of its " in-place " oil is not recommended, owing to variation in residual oil saturation associated with different forms of recovery. The effects of flushing on the estimation of oil saturation are not fully understood, but significant differences in water and oil saturations were observed when coring with water and with oil. The controlling factor may be the mobility factor, which is a ratio of the permeability to oil visc. The visc of oil under water drive may be as high as 35 cp, whereas under gas drive would not exceed 20 to 25 cp.

Samples taken at various depths were examined in the laboratory for oil and water saturations, but comparisons were made difficult, as no cores were available which had definitely not been flushed. The advantages of Electrodrill coring are mentioned.

Field data are reproduced in eight tables. References. A. J. H.

960. Acidizing fundamentals. P. W. Morrison. *Petrol. Tech.*, Sept. 1950, **2** (9), 10–14.—In acidization a group of operators used 8000 to 20,000 gal of acid, one to three stages and acid strengths of 7·5 to 20% with or without additives, all professing satisfaction with the results. Under pressure CO_2 goes into solution, and this reduces the rate of reaction of HCl on limestone, and for completion the time may be increased by 50% or more at pressures in excess of 400 p.s.i. Rates decrease as the amount of dolomite increases, and as the acid concentration increases. The rate of reaction rises with temp, and is lower with oil-wet than with water-wet rock. It is considered that additives to increase or decrease reaction rate confer no significant benefits. Physical additives may be beneficial in tight low-pressure formations.

Limestone porosity and permeability commonly differ from those features in sandstones. Fractures and irregular openings are more common in the former. These features affect acid penetration, and in acid treatment the secondary permeability is increased, channels being widened and plugging material removed. Field experience shows that, in limestone formations with little or no evidence of fracturing, acid treatment gives little improvement in oil production, but fractured limestones show decided improvements without the use of large volumes of acid. Plugging caused by drilling in a well is frequently removed by a small quantity of acid. Controlled treatment is necessary in dealing with multiple zones with variations in permeability so as to create the max potential in each zone. Solution and subsequent cleaning of the avenues affected is essential for improvement in productivity. A zone which fails to clean itself properly is usually one with low energy or secondary permeability.

Strong acid has relatively less water for cleaning, sets more solids free, forms gels

with certain silicates and precipitates iron and aluminium compounds. These bad features probably increase rapidly above 15% concentration. Additives can reduce emulsification and facilitate clean-out. G. D. H.

961. The jet perforation process. W. T. Box and R. F. Meiklejohn. *World Oil*, Mar. 1950, **130** (4), 112–22.—Technical improvements in jet perforators are described, and photographs show test shots. The application to open-hole shooting is discussed. Whether the jet will replace bullet perforating cannot be answered until the jet has been fully exploited. A. H.

962. Shot pattern effect on rock reactions. F. R. Cozzens. *World Oil*, May 1950, **130** (6), 177–80.—Repercussion and reactions may occur months or years after shooting. Gaseous or frothy oil, unexpected gas-heads, dirty fluid, etc., may indicate reactive conditions. For early detection of secondary caving, etc., many operators take sediment samples two or three times per week. If discovered in initial stages trouble may be averted by washing out the shot hole or sand bore. Description of washing method is given. Sharp rise on the pressure gauges at nearby inputs, followed by cloudy or muddy fluid at the affected producer, are the first indication of channel-collapse. Initial corrective step is to provide pressures compatible with its structural stability and gas, if cost not prohibitive, is more satisfactory than water. A. H.

963. Experiments in oil-gas well shooting. Anon. *World Oil*, July 1950, **131** (1), 98–100.—Excerpt from U.S. Bur. Mines, Petroleum and Natural Gas Branch gives (1) correlation of the results of shooting with physical properties of the rocks affected; (2) determination of the physical properties of rocks where shooting is practised: (3) a study of present oil- and gas-well shooting practices in terms of production rate before and after shooting. The experiments include the measurement of strain (and hence the probability of fracture) produced in a rock when shot firing. The equipment required for these measurements had already been developed by the Applied Physics Branch. Results of some preliminary experiments are given. A. H.

964. Water intake profiles on an injection well before and after shooting. D. L. Evans and R. C. Neal, *Producer's Monthly*, Feb. 1950, **14** (4), 20.—In order better to understand the effectiveness of shooting, water-input profiles were correlated with data from diamond coring, core analysis, electric logging, and caliper logging, before and after shooting operations.

The methods of determining input rates were based on the relative advance of brine/fresh water boundary; the two methods may be classified as moving boundary and constant boundary. The boundary is located by a change in solution conductivity, as measured by a probe on an insulated cable.

The practical details are discussed with reference to a particular well at Indian Creek, Penn. It is recommended that the shooting of dry gas sands be avoided, as this results in wasteful water intakes. It was noted that liquid saturation, as well as sand structure, affected the increase of water intake; the greater the saturation, the less marked the effect. A. J. H.

965. New formation fracturing service. Anon. *Petrol. Engr*, Oct. 1950, **22** (11), B-70.—A thickened hydrochloric acid has been used as a formation-fracturing agent and as a solvent. Two non-viscous solutions are pumped simultaneously into the well. On mixing, a thick viscous liquid is obtained. The high viscosity of the solution enables high pressures to be developed, even in permeable formations. After 3 to 4 hr the acid thins down to a water-like consistency and flows back into the well when production is resumed. C. G. W.

966. Interpretation of field data on the basis of relative permeability ratios. F. W. Gooch and M. S. Watson. *World Oil*, Jan. 1950, **130** (1) 135–46.—Several theoretical equations from the literature have been applied to performance data of three volumetric-type reservoirs operated as gas-injection projects. Reasons for deviations from the theoretical curves are discussed. A. H.

967. Alignment charts for permeability calculations. W. D. Elliott. *World Oil*, Sept. 1949, **129** (6), 150.—Two alignment charts are reproduced for the simple, but also accurate, calculation of permeability of test plugs: one chart is designed for use with water-displacement systems, the other for use with volume displacement, or orifice meter. The derivation of the chart constants is explained mathematically.

References. A. J. H.

968. Permeable plastic liner in sand control. W. F. Hower. *World Oil*, Dec. 1949, **129** (9), 170–2.—A solidified plastic, the surface of which consists of a myriad of small openings or pores interconnected in such a manner as to produce a body of high permeability, has been used as a liner for sand control. When plugged with mud the lines are cleaned by backwashing with a sodium tetraphosphate solution. Where a considerable amount of brine is produced with the oil the liners sometimes become partially plugged, apparently with calcium carbonate, since the pores are easily opened again by treating with a small amount of hydrochloric acid. A. H.

969. Paraffin control system uses parallel strings. K. M. Fagin. *Petrol. Engr*, Nov. 1950, **22** (12), B-14.—In this system a 1-inch tubing string is joined to the main tubing string at a point below which paraffin deposits are not found. This macaroni string is clamped to the main string every 100 ft. A plug injection valve is installed on the 1-inch string, and the flow line is connected to the top of the injection valve. A supply tank is connected to the flow line above the injection valve. A by-pass line permits reverse pumping, if the soluble plug becomes lodged in the macaroni string.

The well is pumped through the 1-inch tubing string. A 1-inch soluble plug is periodically pumped down the 1-inch tubing. The supply to the 1-inch line is shut off, and the by-pass into the 2-inch tubing is opened. The soluble plug is thus pumped back into the flow line, where it dissolves. C. G. W.

970. Plastics in gas, water shutoffs. J. F. McDonald. *World Oil*, Mar. 1950, **130** (4), 108–10.—Plastics have been used for shutting-off wells since 1940 with increasing success. To obtain best results, however, careful planning and execution are required. Some factors to be considered before undertaking job are: condition of hole; size of hole; porosity, permeability, temp, and character of formation: gas/oil and oil/water ratios; gas/oil and oil/water contacts; type plastic best suited. The technique followed on two different jobs is described. A. H.

971. Sand consolidation with resins. W. F. Hower. *World Oil*, May 1950, **130** (6), 96–8, 101–2.—Loose sand in a well is banded with phenolic thermosetting-type resin. Sand is first cleaned by pumping back diesel fuel. Resin is added, together with a control penetrant, and pumped into sand and this followed by more diesel fuel. Laboratory and field tests show that permeability is decreased considerably, but since loose sands have high permeability, final result is about average. A. H.

972. Locating abandoned wells. Anon. *World Oil*, Dec. 1949, **129** (9), 175.—Mine detectors have been used to locate cinders from oil steam rigs and thus to localize search for abandoned wells. The m-scope pipe finder has been used effectively in following old lead lines that often are left in place. Bureau of Mines engineers are now experimenting with a piece of equipment with which it is hoped to detect casing in abandoned wells. A. H.

973. Automatic surface safety valve for offshore or isolated wells. C. A. Kizer. *Petrol. Engr*, Dec. 1950, **22** (13), B-16.—This valve, combining the principles of the removable-tubing safety valve, and accurate high- and low-pressure pilot valves, uses the pressure within the valve bore for the energy to close itself.

A valve body contains an inner valve assembly, two pilots threaded into the body at right angles to the line of flow, and a by-pass valve necessary for re-opening the valve.

The construction is such that at predetermined upper and lower values of pressure the pilots exhaust an annular chamber to atm pressure. This results in an unbalanced thrust in the direction of flow, and the valve is seated by this thrust against the action of a spring. When in its closed position the annular chamber can no longer build

up to the tubing pressure, and the valve can only be opened by opening the by-pass valve.

Advantages of the system are : (1) packing-less pilots ; (2) no control packed off to atmosphere ; (3) frictionless operation. A modified version of the valve is available for cases where it is desirable to instal a safety shut-off upstream of the choke.

C. G. W.

974. New plug seal nipple makes possible simplified economical Christmas tree. J. P. Gould. *Oil Gas J.*, 28.9.50, **49** (21), 81.—A nipple is described which simplifies Christmas-tree construction and enables instruments to be run simply into the casing annulus.

The device consists of a plug with a tapered face which can be screwed into the nipple to seat on a tapered seat. Unscrewing one half-turn permits fluid to pass through ports to any desired connexion fitted to the plug.

Leakage along the plug threads is prevented by an O-ring of packing.

Applications of this device are described : (1) to casing heads in place of a bull plug ; (2) in Christmas trees, thereby enabling the number of fittings to be substantially reduced ; (3) for running instruments into the annulus. C. G. W.

Oilfield Development

975. World production. D. M. Duff. *Oil Gas J.*, 24.8.50, **49** (16), 99.—In June world oil output is estimated to have been 10,438,000 b.d., an all-time record. Venezuela had the record figure of 1,572,000 b.d. Russian-controlled areas are estimated to have given 956,000 b.d. Kuwait and Saudi Arabia attained new peaks with 358,500 b.d. and 562,600 b.d., respectively.

Tables give the May and June 1950 daily outputs by countries, and give the monthly figures for the western hemisphere, the Middle East and all the world except the U.S.A. and Russian-controlled areas for the period July 1949 to June 1950. G. D. H.

976. World production. D. M. Duff. *Oil Gas J.*, 28.9.50, **49** (21), 58.—World oil output averaged 10,574,000 b.d. in July. The U.S. gave 5,504,000 b.d., Venezuela 1,533,300 b.d., the Middle East 1,809,300 b.d., and Russia and eastern Europe 863,600 b.d.

Tables give the June and July daily figures by countries, the Venezuelan July output by companies, and the trends of major areas over the past year. G. H. D.

977. New record output. D. M. Duff. *Oil Gas J.*, 27.7.50, **49** (12), 163.—In May 1950 world crude-oil output averaged about 9,842,000 b.d., a record. December 1948 (9,783,000 b.d.) was the previous record. In May the U.S.A. gave 5,121,000 b.d. ; Venezuela gave 1,252,000 b.d. ; the Middle East 1,639,500 b.d. (Saudi Arabia 550,900 b.d., Kuwait 341,500 b.d., Iran 683,000 b.d.).

Tables give the May and April 1950 daily outputs by companies and by fields for Venezuela. G. D. H.

978. Production outside U.S. at new high—4,710,000 b.d. D. M. Duff. *Oil Gas J.*, 27.7.50, **49** (12), 184.—Excluding Russian-controlled areas, the total crude-oil production outside the U.S.A. averaged 3,852,000 b.d. in the first half of 1950. This is 14.3% greater than in the first half of 1949. Canada gave 62,800 b.d., Colombia 89,300 b.d., Mexico 190,000 b.d., Germany 20,800 b.d., Venezuela 1,404,000 b.d., Indonesia 125,000 b.d., British Borneo, 77,000 b.d., Iran 665,000 b.d., Saudi Arabia 484,000 b.d., and Kuwait 310,000 b.d.

Tables give, by countries, the average daily output for the first halves of 1950 and 1949. G. D. H.

979. 1950 exploration 13 percent above record. Anon. *World Oil*, 1.2.51, **132** (2), 76.—8745 exploratory wells were completed in the U.S.A. in 1950, or 13·3% more than in 1949. 816 new oilfields and 301 new pays were found during the year, compared with 668 and 296 in 1949.

Tables show the results of exploratory drilling in Dec. and twelve months, 1950–1949, by districts, and gas fields and new pays discovered in the U.S.A. in Dec. 1950.

C. A. F

980. First half production points to high average for year. P. C. Ingalls. *Oil Gas J.*, 27.7.50, **49** (12), 178.—In the first half of 1950 the U.S. crude-oil output averaged 5,029,685 b.d., 115,100 b.d. less than for the first half of 1949. Texas averaged 2,035,895 b.d., California 863,226 b.d., and Louisiana 550,414 b.d.

Tables give the U.S. production for the first half of 1950 by states, with comparative figures for eight preceding years. G. D. H.

981. 20,258 wells finaled first half to set a new all-time peak. P. de Armond. *Oil Gas J.*, 27.7.50, **49** (12), 174.—The U.S.A. had 20,258 completions in the first half of 1950 (11,707 oil, 1341 gas, 583 service, 6,627 dry) totalling 74,816,000 ft. 482 were 10,000 to 12,500 ft deep, and eighty-four over 12,500 ft deep. There were 16,489 rotary completions.

Among the 3837 wildcats, 581 found oil and 106 gas. Texas completed 7964 wells, of which 5165 found oil. Texas had 258 oil finds out of 1564 wildcats.

Table analyse the well completions by states according to findings, type, depths, etc. G. D. H.

982. 1950 completions hit record 43,939. Anon. *World Oil*, 1.2.51, **132** (2), 34.—43,939 wells were completed in the U.S.A. in 1950, compared with 40,010 in 1948, the previous record year. Average depth of 1950 wells was 3689 ft, compared with 3558 in the previous year. Increased drilling activity in 1950 was most marked in Texas, Oklahoma, and Kansas.

A table shows well completions in the U.S.A. in Dec. 1950, and cumulative for the year, by states and districts. C. A. F.

983. Oil and gas developments in Arkansas during 1949. D. K. Mackay. *Petrol. Tech.* Sept. 1950, **2** (9), 131–50.—Fifty-six fields in South Arkansas produce oil, gas, or condensate from Cretaceous or Jurassic rocks. In 1949 372 crew-weeks of seismic work, 146 crew-weeks of gravity work, and eighty-nine crew-weeks of magnetic work were worked. Eighty-four wildcats were drilled, four finding oil.

In 1949 oil and condensate production totalled 29,785,413 brl, making the cumulative production 784,918,460 brl. 1949 gas production was 67,974,691 M.c.f. Magnolia, Smackover, Schuler, and Wesson led in production in 1949.

Midway, Schuler, Haynesville, and McKamie-Patton have gas-injection operations, while Magnolia, Wesson, and Atlanta have water-injection projects.

359 wells were drilled in Arkansas in 1949, ninety-five being wildcats, of which six opened new fields. 186 of the field wells found oil.

Twenty-one fields produce gas from lenticular sands in the Atoka formation in Northwest Arkansas. There is no oil production. The gas output in 1949 was 6,900,678 M.c.f.

Short notes are given on new fields, new reservoirs, and extensions. A map shows the distribution of geophysical activity, while tables present data on important 1949 wildcats, and give the salient information on the producing fields. G. D. H.

984. Deep Pennsylvanian reef discoveries spur exploration. K. M. Fagin. *Petrol. Engr*, Dec. 1950, **22** (13), B-7.—Four deep Pennsylvanian reef fields have recently been discovered in the northern part of the Midland Basin, Texas. They are the Ropes, Wellman, Cotten, and Adair fields. Initial production rates were high, varying from 900 to 2280 b.d. of 42/43° oil. G.O.R. was low. The fields are being developed on 40-acre spacing.

The reefs are not as thick as the Scurry reef, and their ages are uncertain. Those at Wellman and Adair are reported to be Lower Permian Wolfcamp, and those at Cotten and Ropes, Upper Pennsylvanian Cisco or Canyon. Depths range from 8600 to 10,200 ft.

Drilling and production practice is briefly described, and specimen electric-log profiles of the field are included. C. A. F.

985. Oil and gas developments in North Texas during 1949. G. W. G. Sinclair. *Petrol. Tech.*, Sept. 1950, **2** (9), 151–65.—2715 wells were drilled in 1949, of which 1521 were oil wells with a combined initial output of 209,864 b.d. There were fifteen gas wells. 128 new fields and extensions were opened. Seventy-one wells tested the Ellenburger; seventeen found oil in this horizon, while nine were plugged back and completed in shallower beds.

2,685,800 brl of gasoline and 49,110,654 brl of crude oil were produced in 1949. The crude-oil output was 1,937,213 brl below the 1948 figure. At the end of the year the cumulative output was 1,095,128,194 brl, and there were 21,021 producing wells, of which 1056 were flowing.

Tables give by fields the output, area, discovery date, number of wells, oil type, producing formation, etc. Important wildcats are listed with the main data, and there are summaries relating to various activities. G. D. H.

986. Ventura Avenue—wonder field. R. Sneddon. *Petrol. Engr*, Sept. 1950, **22** (10), A-43.—In the Ventura Avenue field, California, 700 wells are producing approx 57,000 b.d. Cumulative production is 375 million brl, and total reserves are estimated at 600 million brl. Productive limits are unknown, and reserve estimates are subject to revision.

The field is on an anticline about 17 miles along. The anticline is broken at intervals along its length, and the offset fields of San Miguelito, Padre Canyon, and Rincon may all be part of a large field including Ventura Avenue. There is much faulting within the field, and production has been divided into thirteen blocks. Pay is Pliocene sand, several thousand feet in thickness. There may be some migration of oil from the Miocene and Eocene via faults. The oil zone has been subdivided into the Upper Light, Lower Light (Gosnell Shale), Upper Heavy, Lower Heavy, and Lloyd zones. A.P.I. gravity of the oil decreases with depth, and there is a gas zone overlying the oil zone.

The field was discovered about 1920, and the early wells were drilled with cable tools. The development of the field and drilling problems are described. The most serious drilling difficulties now encountered are lost circulation and corrosion of the water string. Most wells are brought in flowing and later put on gas lift or pump.

A cross-section and location map of the field are included. C. A. F.

987. Production peak. Anon. *Oil Gas J.*, 20.7.50, **49** (11), 62.—In the week ended June 26, 1950, Venezuela's output averaged 1,580,129 b.d. Aramco's Saudi Arabian production averaged 562,640 b.d. in June. G. D. H.

988. New drilling depth records established in 1949. Anon. *World Oil*, 15.5.50, **130** (3), 86–7.—The world's drilling depth record was twice shattered by substantial margins in the U.S. during 1949, viz., 18,734 ft and 20,521 ft. A. H.

989. Oil in western Canada. O. B. Hopkins. *Oil Gas J.*, 3.8.50, **49** (13), 54.—About 18,000 wells have been drilled in Ontario, mostly before 1900, and their cumulative production is just over 30,000,000 brl. In 1945 a small pool was discovered at Becker, and this now gives two-thirds of Ontario's 800-b.d. output.

Active exploration in western Canada dates from 1919, and in 1920 the Norman Wells field was opened. Its reserves are 30,000,000 brl, and sixty-five wells were drilled in the last war. Wet gas was discovered in 1924 at Turner Valley, and crude oil in 1936. The peak output was 28,000 b.d. in 1942; production is now 10,000 b.d. Cumulative production is 95,000,000 brl, with remaining reserves 25,000,000 brl. Gas-distillate fields have been found at Jumping Pound and Pincher Creek.

The Alberta and Williston basins have thick sections of largely marine Cambrian to Tertiary beds. The Devonian has important oil and gas accumulations—Leduc, Golden Spike, and Redwater. The Mississippian produces at Turner Valley, while the Lower Cretaceous gives oil (generally heavy) and gas. Much of Alberta's gas is in the lower part of the Upper Cretaceous, and commercial oil (38°) has recently been found at Joseph Lake.

At the end of 1949 eighty-one seismic parties, twenty-three gravity-meter parties, and one magnetometer party were at work in Alberta, Saskatchewan, and Manitoba. There were a few core-drill parties. Efforts have been concentrated on finding Devonian reefs, for these and the overlying beds have given the main fields. In 1949 784 wells were drilled in Alberta, fifty-eight in Saskatchewan, and three in Manitoba. 203 were wildcats. Exploration cost $100,000,000 in 1949.

Leduc has reserves of 250,000,000 brl. 60 miles away Redwater covers an area 15 miles long and up to 3 miles wide, and has reserves of 500,000,000 brl. Golden Spike has a far thicker zone of oil saturation than Leduc and Redwater. Stettler produces from the D-2 and D-3 zones. No accurate estimate can be made for Golden Spike,

but reserves may exceed 100,000,000 brl. Western Canada's gas reserves are placed at about 7,000,000,000,000 cu. ft.

Producing potential in western Canada is 125,000 b.d., but transportation limits the output to 65,000 b.d. A pipe-line from Redwater to the Great Lakes has been begun. Larger lake tankers are being built (115,000 brl each).

Canada consumes about 300 gal/head of petroleum products (U.S.A. consumes 500 gal/head). G. D. H.

990. Venezuelan review. Anon. *Oil Gas J.*, 7.9.50, **49** (18), 49.—In July eighty-five rigs were operating in Venezuela (forty field, twenty-eight wildcat, 17 workovers and cleanouts). In June there were fourteen geological parties, one structure-drill party, three gravity-meter parties, eleven seismograph parties, and one telluric party at work.

Production averaged 1,585,460 b.d. for the week ended Aug. 14. G. D. H.

991. Outlook for Latin American oil development. L. C. Uren. *Petrol. Engr*, Jan. 1951, **23** (1), A-47.—Current production and economic factors in the oil-producing countries of Latin America are discussed, and the conditions which may influence the future oil development in those countries is reviewed.

Venezuela is the largest producer, 90% of production being available for export. Record production was reached in 1948, and the estimated reserves of known fields are 9 billion brl, or one-tenth of the world's proved reserve.

Mexico produced 62 million brl in 1949, and reserves are officially estimated at 1,270 million brl.

In Columbia peak production was reached in 1949, when 29,643,975 brl were produced. Reserves are estimated at 422 million brl, but recent developments may considerably increase this figure.

Argentina's production reached a peak of 23,992,000 brl in 1949, 50% of the country's requirements. The most important area is Comodoro Rivadavia, which has an estimated reserve of about 300 million brl.

Production in Trinidad has been declining since 1925. 1949 production was 20,616,721 brl. Proved reserves are estimated at only 208 million brl, but exploration is active.

Peru produced 14,650,000 brl in 1949, and reserves are estimated at 148 million brl.

Ecuador produced 1,859,480 brl in 1949, a slight increase over 1948. Reserves are small and estimated at 22 million brl.

Production in Bolivia is expected to expand. The fields produced 578,000 brl in 1949.

Brazilian production comes from six small fields in Bahia near the Atlantic coast. They produced 100,000 brl in 1949.

Chile commenced commercial production in Nov. 1949. 46,000 brl were produced from the Spring Hill field in the last two months of 1949.

Small production has been obtained in Cuba, and there has been exploration in Paraguay and in Panama. C. A. F.

992. France's 1949 production is higher than 1948's. Anon. *Petrol. Engr*, Nov. 1950, **22** (12), B-77.—French production in 1949 was 415,220 brl, compared with 361,350 brl in 1948. In France and French overseas territories, seventeen geophysical crews were operating in 1949, and in the same year seventy-eight wells, of which forty-nine were oil producers and five gas, were completed in the French Union. C. A. F.

993. Summary of petroleum exploration activities in France and the French Union. Anon. *Rev. Inst. franç. Pétrole*, 1951, **6**, 32–5.—Development wells (5758 m) and wildcats (76,596 m) drilled in the first half of 1950 are tabulated, according to operating company, together with a forecast for the second half of 1950. Total French daily production rate on July 1, 1950, was 613 m^3 crude and 695,000 m^3 gas. V. B.

994. Abqaiq—world's largest producer. P. Reed. *Oil Gas J.*, 3.8.50, **49** (13), 42.—Abqaiq is producing 450,000 b.d. The 1068-mile 30- and 31-inch trans-Arabic pipeline will hold 5,600,000 brl. Current production is from forty-five wells; a further fifteen are producers, and there are five observation wells.

Abqaiq was discovered in 1941. It is 30 miles long and 6 miles wide. Most oil

comes from the Arab D limestone zone; the C zone at 6000 to 6200 ft gives 33° A.P.I. oil. Reserves are estimated at 4,000,000,000 brl. Ain Dar has nine wells and Qatif ten wells. Four wells have been drilled at Haradh, but there are no production facilities. The Abu Hadriya field was opened at 10,220 ft in 1938.

It is estimated that six rigs will be able to maintain the Saudi Arabian output at 500,000 b.d. for the next ten years. Dammam has a primary spacing of 6000 ft along the contours. Initially the oil was undersaturated; the reservoir is essentially under dissolved-gas drive. There is limited water influx. In 1950 the pressure drop has been 0·9 p.s.i/1,000,000 brl, and throughout it has been 1·7 p.s.i/1,000,000 brl. The G.O.R. is 900 cu. ft/brl at Abqaiq and Qatif. The Abqaiq wells are completed barefoot. 7-inch casing is set in anhydrite 10 to 15 ft above the pay. G. D. H.

995. Kuwait oil progress. V. S. Swaminathan. *Petrol. Engr*, Dec. 1950, **22** (13), A-46.—Oil operations in Kuwait in the Persian Gulf commenced in 1934. Following preliminary geophysical surveys in the state, a wildcat was drilled at Bahrah. This was abandoned as dry, but a second well at Burgan found Cretaceous oil at 3672 ft in 1938. Prior to 1942, when operations were abandoned, a further eight wells were drilled on the Burgan structure.

Post-war development has indicated the field to be the world's largest pool. At the centre of the structure the pay zone, which includes three main sands, is 1100 ft thick. Pay is Middle Cretaceous sand, and reserves of the field are estimated at 11 billion brl. Eighty-six wells, mostly dual producers, had been drilled by the end of 1949, and the drilling programme has now been curtailed. Well spacing is 600 acres. Daily average production in 1949 was 246,752 brl, and the year's production was 89,930,444 brl. Crude is paraffinic–asphaltic mixed base.

Two gathering centres were commissioned in 1949, each carrying approx 100,000 b.d. Separation is seven-stage, and horizontal separators are used. Gathering centres have an initial separating pressure of 425 p.s.i. A refinery, consisting of a topping unit, refractionator, and doctor-sweetening plant is now in operation. Throughput is 25,000 b.d. Crude is pumped from Burgan to the tank farm at Ahmadi.

An oil-loading pier, completed in 1949 at Mena Al Ahmadi, can berth six tankers, and is the largest of its type.

Personnel welfare is briefly described. C. A. F.

996. Kuwait's production may show 37 million gain. Anon. *World Oil*, 1.2.51, **132** (2), 224.—Kuwait production for 1950 is expected to exceed that of 1949 by 37 million brl. 114,649,401 brl were produced in the first eleven months of 1950. C. A. F.

Transport and Storage

997. The world's largest tankers. Anon. *Motor Ship*, Jan. 1951, **31** (370), 292.—Details, with photographs, are given of the 15½-knot *Bérénice* and her sister ship *Bethsabée*, owned by Cie Auxiliaire de Navigation. These ships have a deadweight capacity of about 31,300 tons, and are equipped with twin-screw, two-stroke, single-acting propelling machinery of standard Burmeister and Wain type operating on boiler oil. Each engine has eight cyl with a dia of 740 mm and a piston stroke of 1400 mm, and develops 6700 b.h.p. at 121 r.p.m. The boiler oil will be passed through Titan self-cleaning centrifugal separators, and fuel tanks, extending to main deck, are provided with heating coils. *Bérénice* was recently launched, and will be completed during 1951; *Bethsabée* was only recently laid down. Comparative figures of deadweight capacity, length, beam, and depth are given for these two ships and five others of 30,000 tons deadweight capacity and upwards. U. M.

998. Oil tanker progress. R. Hammond. *Petroleum*, Nov. 1949, **12** (11), 277–80.—Reviews the vast programme of tanker construction proceeding in British, Scandinavian, French, and American shipyards including details of some particular ships. From statistics given, the trend towards increased size and speed is apparent.

A description is included of the oil-tank-cleaning barge *Interknit*, built for the Port of London Authority. This has been designed and fitted with plant for removing

in a safe and rapid manner gases and oil sludge from the fuel or double-bottom tanks of ships. Corrosion and other problems and possible future developments are considered. R. E. P.

999. The T.E.S. "San Silvestre." Anon. *Petroleum*, Nov. 1949, **12** (11), 281–3.—A description of the main features of the all-electric tanker, which is of 15,900 deadweight tons, 510 ft in length, extensively electrically welded and is equipped with a single screw powered by a 9000-s.h.p. propulsion motor, taking supply from a three-phase 3320 V alternator coupled to a high-pressure turbine. R. E. P.

1000. The "World Liberty." Anon. *Petroleum*, Nov. 1949, **12** (11), 285.—Basic data, dimensions, and brief details of the new 28,000 deadweight-ton tanker. R. E. P.

1001. New tankers for Shell. Anon. *Petroleum*, Nov. 1949, **12** (11), 284–5.—Constructional details are given of one of four new tankers (28,000 tons deadweight) ordered by the Shell Oil Co. to carry crude oil from the Middle East. R. E. P.

1002. Oil handling facilities at ports. Anon. *Petroleum*, Nov. 1949, **12** (11), 286–7.—The design and construction of a modern oil harbour is outlined, using as an example the work proceeding at Le Havre. Emphasis is placed on safety considerations and rapid unloading and mooring of tankers. R. E. P.

1003. Installation of offshore flow lines. H. E. Denzler, J. W. Scott, and J. M. West. *World Oil*, Feb. 1950, **130** (2), 127–30. (*Paper read before Petroleum Branch, AIME, San Antonio.*)—Handling the production from offshore wells in the Gulf of Mexico has presented problems which are still far from satisfactory or economical solution. The methods tried by the California Co. are discussed. The method adopted consisted of min facilities offshore and a pipeline to a shore terminal. The difficulties experienced in the installation of 2-inch and 14,400 ft of 4-inch dia lines are also discussed. A. H.

1004. Tapping pipe lines under pressure. A. M. Hill. *World Oil*, Feb. 1950, **130** (2), 176–8.—Tapping into oil or gas lines under pressure is a hazardous operation and best carried out by a machine. A tapping and plugging machine as used by Standard Pipe Co., for the last fourteen years is described and its uses discussed. It can be used also in the removal of sediment and water from the bottom of oil-storage tanks. A. H.

1005. Gear shift starts cold oil. E. Weaver. *World Oil*, Feb. 1950, **130** (2), 174.—The starting of a column of cold crude through a 10-mile line of 4-inch pipe in the East Texas field area caused considerable clutch wear until the 90-h.p. engine was replaced by a 40-h.p. engine with standard truck-type transmission. When oil has begun to move with sufficient speed to break the "set," the gears are shifted into high and full throughput is attained. A. H.

1006. Gas heat exchangers in transmission systems. F. S. Young. *World Oil*, May 1950, **130** (6), 200–3 (*Read before a regional mtng of the N.G.A.A. Amarillo*, Dec. 1949).—The transmission of large quantitites of natural gas requires vast amounts of power, and this in many situations presents a waste-heat-disposal problem. At some stations there is little water available, and atm temp varies between wide extremes. The gas on the suction side of a station is at a uniform low temp after travelling underground, and often provides a useful heat sink. Additional horsepower required to put gas through a gas (etc.) to gas-heat exchanger is not excessive, and the use of this method of heat disposal, in connexion with: (1) glycol dehydration plant; (2) engine-oil cooling; and (3) still overhead cooling in a small-field desulphurization plant, is discussed. A. H.

1007. Design of heaters to eliminate freezing and hydrate formation. H. R. Wotman. *World Oil*, June 1950, **130** (7), 267–8.—Where dehydration of natural gases is not practicable, freezing and hydrate formation can be avoided by heating. Four methods are available: (1) electrical strip heaters, though cost is usually prohibitive; (2)

direct-fired heaters, using flue gases; (3) hot water; (4) steam. Although "Q" will vary with gas velocity, etc., typical values found are 50 to 75 B.ThU/hr/°F/sq. ft. for hot-water exchangers and 5 to 10 for a direct heater. A. H.

1008. Centrifugal compressors for pipeline duty. J. E. McCarthy. *World Oil*, Sept. 1949, **129** (6), 187.—Two typical stations of the "Big Inch"—24-inch dia—and the "Little Big Inch"—20-inch dia—lines are surveyed. The centrifugal compressors are arranged in a series of five, driven directly by electric motors, and separated from the latter by a fire wall; the motors are force-ventilated. The design of the station had been over-shadowed by the condition that the stations be convertible from gas- to oil-pumping within a period of ninety days.

The design, construction and performance characteristics of the centrifugal compressors are treated separately; unit specifications are given. A. J. H.

1009. Foundation stabilization whips quicksand problem. A. Gibbon. *World Oil*, May 1950, **130** (6), 193–4.—Standard Pipe Line Company's Carrollton main-line pumping station had been built above two strata of quicksand. When extensions to the plant were required the strata were stabilized with pressurized cementing. Pattern and method are described. A. H.

1010. Through-flow desurger minimizes line shock. J. H. Dawson. *World Oil*, Dec. 1949, **129** (9), 192–200.—A piece of equipment, which has proved efficient in absorbing shock waves due to "water hammer" and pump pulsations, is described. A diaphragm-type sleeve is placed concentrically and outside the flow line. Under the sleeve there are throttling orifices drilled through the wall of the line. Air pressure is applied on the outside surface of the sleeve. As a shock wave passes along the line fluid flows through the orifices, and extends the sleeve against the pressure of the air. As the line pressure decreases, the fluid is forced back through the orifices by the compressed air. On each passage the orifices absorb much of the energy. A. H.

1011. Small infractions create major errors in flow-meter measurement. J. P. Squier. *Oil Gas J.*, 18.1.51, **49** (37), 60.—Sources of errors in accurate measurement of fluids by the flat-plate orifice-type flow-meter are discussed. A major source of error is the alteration of the differential pen arc to the lines of arc on the chart, usually made by inexperienced personnel in order to produce a better flow of ink.

The lag or space between the static pen and the differential pen often produces large errors.

Twenty-four-hr clocks should be used instead of seven- or eight-day mechanisms, since at least the charts must be renewed once a day, ensuring a daily visit.

The article is illustrated by examples from a number of charts. G. A. C.

1012. Material control on the transcontinental gas pipe line. J. E. Kastrop. *World Oil*, Dec. 1949, **129** (9), 187–90.—To maintain accurate control over the flow of material entering such a project as the $242 million Transcontinental Pipe Line Construction is not only a large undertaking, but is also essential if it is to be completed on schedule. The organization set up to handle this problem is described. A. H.

1013. Simplified loop line gas flow equation. J. I. Morris. *World Oil*, May 1950, **130** (6), 205–6.—In the design of high-pressure natural-gas transmission systems it is often desired to use a system comprised of parallel or looped lines. The Weymouth or other gas-flow equations are usually used by substituting equivalent diameters and/or equivalent lengths. *U.S. Bur. Mines Monograph* 6 gives the following equations to determine equivalent length and dia.

$$L_1 = L_2(d_1/d_2)^{16/3} \qquad d_1 = d_2\left(\frac{L_1}{L_2}\right)^{16/3}$$

where L_1 is the equivalent length of any pipe length L_2 and dia d_2 in terms of dia d_1; d_1 is the equivalent of any pipe of dia d_2 in terms of dia d_1.

Using the same basic assumptions and looping with pipe of the same dia, the follow-

ing equations are developed for a system consisting of two complex parallel pipe systems.

$$L_{es} = L\left(\frac{f}{N_1^2} + \frac{1-f}{N_2^2}\right) \text{ miles of dia } d$$

$$\left(\frac{Qc}{Q}\right)^2 = \frac{N_1^2 \times N_2^2}{N_2^2 f - N_1^2 f + N_1^2}$$

$$f = \frac{N_1^2}{N_2^2 - N_1^2}\left(\frac{N_2^2 Q^2}{Qc^2} - 1\right)$$

where f is the fractional length of the overall system paralleled by N_1 number of pipes; N_1 is the No. of parallel pipes in the remaining length; L is the overall length of system—miles; Q is the single line capacity; L_{es} is the equivalent length of system—miles; Qc is the complex line capacity. A. H.

1014. Kilowatt hours and cubic feet by the billion. W. T. Thagard. *World Oil*, Feb. 1950, **130** (2), 169–74. (*Presented before the 21st Ann Mtng of Petroleum Electric Power Ass., Beaumont*).—Transmission of natural gas through the " Big and Little Big Inch " lines is largely dependent on electric power. The Big Inch consisted of 1264 miles of 24-inch and 130 miles of 20-inch pipe with twenty-seven pumping-stations. The Little Big Inch was approx 1475 miles long with thirty main-line stations. It is estimated that about 3 kW/hr are required per M.c.f. or about 370,000 kW/hr per year per mile of 20-inch pipe. The conversion of the pumping-stations from oil to gas by Texas Eastern Transmission Corp., is discussed. A. H.

1015. Dehydration of natural gas. R. C. Buchan, R. J. Sullivan, M. Williams, and H. H. Spain. *World Oil*, May 1950, **130** (6), 148–60. (*Substantially as presented before the Spring Mtng, A.P.I. Divn of Prod., Dallas*).—Dehydration of natural gas has become a necessity in many fields in which high-pressure gas is handled. With relatively low-pressure-gas systems trouble was usually encountered only during very cold weather. As pressures increased to about 1000 lb, freezing troubles increased considerably. The methods of overcoming this problem in the Gulf Coast area are discussed. A map of the area shows the min ground temp at a depth of 18-inches, and charts show the gas temp to be expected in lengths of pipe. Katz curves for predicting hydrate formation and permissible expansion of a 0·6 gravity natural gas are reproduced. The line trap and data on an experimental installation are given. The Glycol type gas dehydrator is discussed, and a photograph shows a 20 to 25 M.c.f/day plant. The absorber pressure is a variable which affects results, and the optimum pressure is about 700 to 800 p.s.i., using diethylene glycol and about 1000 p.s.i. with triethylene glycol. At about 250 p.s.i. the water content of the treated gas is approx 2½ times that obtained at 750 p.s.i. In the dry-bed type dehydrator activated alumina has given slightly better results in regard to capacity, but fluorite apparently withstands attrition better. For gas temp above 100° F silica-gel beads are recommended. Combination units have also been used to advantage. The line trap has the advantage of simplicity, the dry-type dehydrator is higher in cost than the wet-type but can obtain the lowest water content. A table gives operating details and cost of twelve plants. A. H.

1016. Operating and design features of adsorption-type dehydrators. M. L. Riley. *World Oil*, Jan. 1950, **130** (1), 184–6.—Application of adsorption processes to high-pressure systems has permitted gas-transmission companies to reach optimum line pressures without formation of gas hydrates. A typical unit and economics of a number of drying–regeneration cycles are discussed. A chart showing moisture content of saturated gas at various temp and pressures is given. A. H.

1017. New vacuum blasting tools and welding, drum cleaning. D. H. Stormont. *Oil Gas J.*, 11.1.51, **49** (36), 78.—Special blasting guns, an abrasive separator generator, and a vacuum-pump dust collector are made use of in a new cleaning tool for automatic cleaning of exterior surface of steel drums before painting, and for blasting edges of steel plate prior to rolling and welding into pipe.

Paints, scale, and rust can also be removed from tanks, rail cars, steel, or any other surface which can be cleaned with abrasives. G. A. C.

Refinery Operations

Refineries and Auxiliary Refinery Plant

1018. New Punta Cardon refinery will be second largest in Venezuela. V. S. Swaminathan. *Oil Gas J.*, 1.2.51, **49** (39), 54.—The 60,000 b.d. refinery at Cardon, Venezuela, includes distillation, cracking, cracked-products separation, and products-treating units. A harbour for handling up to 20,000-ton deadweight tankers and a modern town for 12,000 people were also built. G. A. C.

1019. British refineries (No. 6) The Shell chemical plant, Stanlow, Cheshire. Anon. *Petroleum*, Sept. 1949, **12** (9), 226–30.—Briefly describes the economic advantages, geographical location, history of the plant, and some of the processes used. The initial range of solvents being produced includes : *iso*propyl alcohol, *iso*propyl ether, acetone, diacetone alcohol, mesityl oxide, and methyl *iso*butyl ketone, all from propylene ; and *sec*-butyl alcohol and methyl ethyl ketone from butylene. R. E. P.

1020. The Normandy refineries. Anon. *Petroleum*, Oct. 1949, **12** (10), 247–51.—Describes the remarkable recovery made in the French petroleum industry since the war, and more particularly of the Normandy refineries. Diagrams, flow-sheets, and tables of products are included in the description of the refineries at Petit-Couronne, Gonfreville, Port-Jérôme, and Gravenchon. R. E. P.

1021. Fractionating unit stabilizes crude oils, natural gasoline. Anon. *Refiner*, 1950, **29** (11), 151–2.—Crude and natural gasoline are mixed, thus requiring only one pipeline for transportation and eliminating stabilizers and fractionators from gasoline plants (only the conventional de-ethanization of the raw natural gasoline being necessary). At the refinery the gasoline must be separated. A flexible fractionation unit, operating over a wide range of mixtures, may be provided to do this, simultaneously stabilizing the crude, which simplifies subsequent refining. Such a unit, operating on as much as 600 brl/hr, is briefly described. R. W. G.

1022. New oil blending plant, one of the largest in country (U.S.A.). Anon. *Refiner*, 1950, **29** (11), 123–4.—Cities Service Oil Co. has started operations at its new Chicago terminal and compound plant, which will compound, blend, package, and ship 25 million (U.S.G.) of lubricating oil annually. The installation is described. R. W. G.

1023. Planning refinery heat transfer equipment. Part III—Economical Proportions. T. G. Hicks. *Refiner*, 1950, **29** (11), 113–15 (see Abs. Nos. 391, 610, 1951).—The first two parts of this series discussed heat-transfer calculations applicable to refinery, natural gasoline, and petrochemical plant. This last one discusses economic equations and calculations. It is pointed out that the series is merely designed to assist choice of equipment and that final details should be left to the manufacturers.

Items considered include choice of tube and lengths and diameters, baffles and flows. Equations are given for estimation of economical pumping velocities and cooling water flow. Several relevant graphs and figures are given and an illustrative calculation presented. R. W. G.

1024. Mechanical shaft seals for general refinery service. A. Fanestiel. *Oil Gas J.*, 1.2.51, **49** (39), 56.—Use of conventional packings, double and single mechanical shaft seals, and seal oil with packings is described. Which packing to employ depends on operating conditions, economic, and safety aspects of the particular application.

High-temp thermoplastic materials, resistant to organic and inorganic solvent and corrosive agents, are used in single mechanical seals for requirements found in a petroleum refinery, except for service above 400° F. Instructions to personnel operating centrifugal pumps equipped with single mechanical seals are summarized. Seven figures illustrate the article. G. A. C.

1025. Importance of oilburner nozzles. Part 1. Factors controlling the delivery rate and spray pattern. K. J. Whittet, H. G. Murray, and C. L. White. *Fueloil & Oil Heat*, Nov. 1950, **9** (11), 58.—Essential burner parts controlling fuel delivery are the pump, pressure-regulating valve, and nozzle. The nozzle primarily controls the fuel rate, atomization, and spray pattern of the oil. It consists of four essential parts, a fine-mesh strainer, a disc stem with tangential slots, a conical swirl chamber, and an orifice. Nozzles are calibrated to deliver oil at a fixed rate and spray angle. Calibration of nozzles is discussed in some detail. Nozzles from 0·5 to 3 g.p.h. were tested over a range of pump pressures to determine effect of pressure on fuel-delivery rate. Results showed that as pump pressure was increased the fuel rate increased about 3·5 to 4% for each 10 lb change in pump pressure. Rate of change varied slightly among individual nozzles. A comparison of fuel rates of kerosine and other fuels was made. A chart shows the pressure-curves of each fuel to be approx parallel at pump pressures above 80 lb. Laboratory tests indicate that fuel-delivery rate of a nozzle is decreased about 1%, by vol for every 10° F rise in temp between 20° and 80° F. The following factors were found to control nozzle temp: actual fuel rate, radiant heat emitted by the glowing surfaces of the combustion chamber, and the amount of excess air. Other factors affecting oil flow include condition of slots and cleaning of nozzles. D. K.

1026. Standardized boiler units. C. E. Miller. *Mech. Engng*, Jan. 1951, **73** (1), 9.—As far as standardization of equipment is concerned, much progress has been made in recent years in the manufacture of boilers. This is probably partly due to the necessity of increasing production during emergency, but mostly to the realization by the consumer of the benefits of standardization, viz., lower capital investment, quicker delivery, and simplified engineering. In addition, the standardized boiler has brought important advantages such as savings in operation because of improved efficiency, the ability to burn cheaper fuels, reduced maintenance, and greater reliability. In view of the fact that there is a need for replacing more than 150,000,000 lb of existing steam-generating capacity, the subject of standardized boilers is one of immediate interest. They are generally available in capacities up to about 60,000 lb of steam per hr at operating pressures in the range from 100 to 400 p.s.i. Usually they supply saturated steam only, but standard superheaters are available in a number of designs. Oil and gas firing is used for all sizes. The paper discusses in detail the more important basic design principles of standardized boilers, and covers such items as support, furnace, circulation, convection surface, casing, and fuel. Typical examples are considered of the application of the principles put forward. A. S.

1027. Eccentric rotary pumps. A. W. Sleeswijk. *Ingenieur*, 5.1.51, **63** (1), W. 1; 19.1.51, **63** (2), W. 11.—A surveys of the known variations of the eccentric rotary positive-displacement pump, and mentions by name the inventors of these units. Numerous detail-sectioned drawings are included, and a large proportion of the text is given over to the mathematical complexities involved in the design of such pumps. R. R.

Distillation

1028. Multicolumn reflux still promises large savings of time, labour and materials. Anon. *Refiner*, 1950, **29** (11), 140–1.—A description of the multi-column counter-current molecular still designed by Dr S. L. Madorsky of the U.S. Bureau of Standards. It is claimed to have significant advantages for the commercial separation of liquids which differ in mol. wt. or vapour pressures, but have similar properties otherwise. Suggested possible applications are concentration of vitamins from natural sources, purification and concentration of vegetable oils, lubricating oils, and high-boiling petroleum fractions. R. W. G.

1029. New L.P.G. unit takes charge from polymer de-propanizer. H. F. Thompson. *Petrol. Process.*, 1950, **5** (8), 841.—A short description is given of a new 1100-b.d. liquefied-propane-gas unit which was recently placed on stream at the Marcus Hook refinery of the Sinclair Refining Co. The L.P.G. unit contains a twenty-tray de-ethanizer tower recovering 85 to 90% of the C_2 content of the feed from the de-propanizer tower of a catalytic polymerization unit. The L.P.G. from the de-ethanizer is cooled and dried by activated alumina. D. W. F.

1030. Patents. R. Robertson, assr. to Standard Oil Development Co. U.S.P. 2,513,252, 27.6.60. Diolefins of over 98% purity are obtained by distillation of a contaminated diolefin stream having 1 to 4% by vol of a high-boiling gas oil.

I. T. Krohn, assr to Ethyl Corpn. U.S.P. 2,513,654, 4.7.50. A process of separating by steam distillation an alkyl lead from the reaction products of its synthesis and carrying out the distillation with an aqueous solution of an iron salt.

H. J. Madden, assr to Ethyl Corpn. U.S.P. 2,513,659, 4.7.50. A process of recovering an alkyl lead from the reaction products of its synthesis by steam distilling the reaction mass with an aqueous solution of an iron salt and sodium thiosulphate.

W. H. Rupp, assr to Standard Oil Development Co. U.S.P. 2,514,294, 4.7.50. The distillation of C_1 to C_6 hydrocarbon mixtures. C. F. S.

Absorption and Adsorption

1031. How to test operating efficiency of a natural-gasoline plant. J. B. Armstrong. *Oil Gas J.*, 11.1.51, **49** (36), 93.—Tests to determine the overall operating efficiency of the absorption section of a natural-gasoline plant, as applied to extraction of L.P.G. and gasoline, are discussed, and a plant-test-data summary sheet given.

The test consists of several phases, including preparation for the test, accumulation of operating data, and samples for analysis during period of steady operation, analysis of results to show accuracy of data and reliability of test, determination of extraction efficiencies, product losses, and inefficient and costly operations, and recommendation of corrective measures necessary to obtain more efficient plant operation. G. A. C.

1032. Influence of production practice upon natural gasoline recovery. B. H. Sage. *Oil Gas J.*, 1.2.51, **49** (39), 65.—The influence of production methods upon the character of the hydrocarbons available for natural-gasoline-plant operation from condensate fields is indicated; and the effect of cycling upon the composition of the plant feed is estimated semi-quantitatively.

Involved in these calculations are a number of assumptions; and the effects of non-equilibrium conditions cannot be evaluated with accuracy.

Results indicate a much greater quantity of components of intermediate volatility recovered from an underground reservoir by the use of pressure-maintenance technique than is to be expected with more conventional procedures. Calculations indicate that approx 15% of the propane and 37% of the pentanes and heavier would have remained underground at the time field pressure had been decreased to 10% of its original value if cycling or pressure maintenance had not been carried out.

Effect of non-equilibrium behaviour upon the recovery of natural gasoline from the gas phase of the reservoir is briefly considered. G. A. C.

1033. A system of process calculations for light hydrocarbons, Part II—Equilibrium considerations. A. J. L. Hutchinson. *Refiner*, 1950, **29** (11), 117–22 (see Abs. No. 658).—The series is concerned with a method of using printed forms to expedite the work of process-plant calculations. Part I treated the basic principles upon which light-hydrocarbon process-plant calculations and designs are made. Part II presents a consideration of vapour–liquid flash computations, introducing printed forms for calculations. It is claimed that these forms present an orderly procedure and greatly reduce time spent on such calculations. R. W. G.

Solvent Extraction and Dewaxing

1034. Wax and lube-oil manufacture at Sinclair's East Chicago plant. Anon. *Oil Gas J.*, 18.1.51, **49** (37), 50.—New designs have been incorporated in the propane de-asphalting, phenol treating, and M.E.K. dewaxing of oils at the East Chicago refinery; thus replacing former acid-treating and wax-treating plants.

The propane de-asphalting unit has two 10 × 53-ft treating towers connected in parallel, performing at rates up to 5000 b.d. through one with a 6 to 1 propane ratio.

In comparison with earlier units the M.E.K. plant has been increased in size to take

advantage of additional capacity found in filters and double pipe exchangers; and design includes elimination of a decanter and elimination of controlled flow of blanketing flue gas through filter hoods.

Flow sheets are provided, and tables show phenol and M.E.K. unit yields—design versus actual operation; and characteristics of neutral and residual dewaxed oils are tabulated. G. A. C.

Cracking

1035. Catalytic cracking. Part IV. M. Sittig. *Refiner*, 1950, **29** (11), 125–32. (See Abs. Nos. 2, 60, 2715, 1950 and 632,1951.)—This last of the series considers the Suspensoid cracking process, hydrocracking and hydroforming, relative merits of fixed-bed and moving-bed processes, effect of process variables on conversion, factors affecting product distribution and product quality, and finishing of cat cracked gasoline. Cracking cat, composition, properties, and manufacture are also discussed, together with laboratory work on cat cracking, pilot-plant development, and plant control.

It is stated that Suspensoid cracking (developed by Imperial Oil Co. Ltd., of Canada, at Sarnia, Ontario, refinery) represents a compromise between thermal and cat cracking. Additional operating costs over thermal cracking are estimated at 12 cents (U.S.) per brl of fresh feed (much less than cat cracking), and savings in T.E.L. alone should justify this cost.

A further fifty-nine references to the literature brings the total for the series to 176. R. W. G.

Polymerization

1036. The diffusion of polystyrene in different solvents. P. Z. Adelstein and C. A. Winkler. *Canad. J. Res.*, 1950, **28**, 194.—The variation of the diffusion coefficient of polystyrene with mol. wt. in bromobenzene, toluene, and methyl ethyl ketone, obtained with a modified Northrop cell, obeyed the relation $\frac{1}{D} = AM^E$, where A and E are empirical constants. The mol. wt. (determined by visc measurements) of the samples varied from 300 to 560,000. Both the exponent and the ratio of the diffusion constants of a low- to high-mol.-wt. sample increased in better solvents, indicating that in such solvents the polystyrene molecules are elongated. Using this ratio as a criterion of solvent power, there is good agreement with the results of swelling and precipitation studies. No quantitative relation has been obtained between diffusion coefficient and concentration, but the concentration effect is similar for both high- and low-mol.-wt. samples. The decrease in the diffusion coefficient–solvent visc. product for a low and a high mol.-wt. polymer in good solvents suggests an increase in the degree of solvation of the polymer. The variation of this product with solvent composition in solvent mixtures indicates the existence of selective solvation by the good solvent. The activation energies of diffusion were of the order of 3 K.cal. for both high- and low-mol.-wt. polymers in good and poor solvents. This supports Eyring's theory of segment flow for polymer diffusion. A. D.

1037. Production and properties of 2 : 3-butanediol. XXVI. Linear polyesters of 2 : 3-butanediol. R. W. Watson, N. H. Grace, and J. L. Barnwell. *Canad. J. Res.*, 1950, **28B**, 652.—Several new polyesters have been prepared from levo 2 : 3-butanediol using ethyl oxalate, ethyl malonate, dimethyl terephthalate, maleic anhydride, succinic, glutaric, adipic, azelaic, and sebacic acids and from *meso*-2 : 3-butanediol using phthalic anhydride. The purified polyesters, except the polymalonate, appear to be composed of regularly recurring acid and diol segments over the mol.-wt. ranges investigated. They are all amorphous resins or balsams. A. D.

1038. The thermal decomposition of styrene–butadiene popcorn polymer. J. Halpern and C. A. Winkler. *Canad. J. Res.*, 1950, **28**, 5–16.—Popcorn polymer was synthesized by allowing the monomer mixture of styrene and butadiene to polymerize at 50% in the absence of air or catalysts. Polymers were prepared with butadiene contents ranging

from 2·00 to 31·65 mol. %. It is because of its opaque appearance and proliferative activity that it has come to be known as popcorn polymer.

At temp of the order of 250 popcorn polymer undergoes decomposition to soluble polymer. The decomposition was studied in sealed tubes, as air brought about oxidative degradation more rapid than the purely thermal decomposition. The reaction is catalysed by peroxides present in the popcorn when the latter is formed. These peroxides could be removed by extracting the polymer with benzene at 80%. The kinetics of both the catalysed and purely thermal reactions were investigated. The rates of both decompositions are first order, but the catalysed reaction has a higher activation energy and a higher frequency factor. The rate of the thermal reaction decreases, and its activation energy increases with increasing butadiene content of the polymer. A linear relation between the activation energy and the log of the frequency factor for the decompositions of popcorn polymers of different butadiene contents was observed. The rate of increase of the swelling index of the insoluble polymer during the decomposition was also determined.

The results indicate that the rate of solubilization is determined by the activation energy of the bond-scission process and is independent of the degree of cross linking of the polymer. A. D.

1039. Patents. R. B. Thompson and H. S. Bloch, assrs to Universal Oil Products Co. U.S.P. 2,512,698, 27.6.50. The polymerization of aromatic polyfulvenes at a temp from about 25° to about 300° C to produce a resinous material. The aryl radical is attached to the acyclic carbon atom of each of the fulvene radicals.

S. S. Kurtz, assr to Sun Oil Co. U.S.P. 2,513,183, 27.6.50. Copolymer products are made by polymerization of butadiene and styrene and a small amount of a tacky substance.

M. W. Swaney and A. H. Gleason, assrs to Standard Oil Development Co. U.S.P. 2,513,244, 27.6.50. A process of polymerizing butadiene-1 : 3 to prepare resin-containing polymerization products, by heating butadiene-1 : 3 and piperylene at a temp between 130° and 200° C until a large part of the diolefin is converted to a cyclic dimer, increasing the temp 280° to 400° C and maintaining at this temp in the absence of oxygen until the dimer is converted to the product. C. F. S.

Isomerization

1040. Patent. H. J. Passino, assr to M. W. Kellogg Co. U.S.P. 2,513,103, 27.6.50. Isomerizing aliphatic paraffin hydrocarbons using hydrogen fluoride and boron trifluoride in the presence of a low-boiling *iso*paraffin as a cracking inhibitor. C. F. S.

Chemical and Physical Refining

1041. The chemistry of the acid treatment of gasoline. G. E. Mapstone. *Refiner*, 1950, **29** (11), 142–50.—An extensive review of the chemistry of the acid treatment of gasoline which gives what the author describes as near as possible a complete list of the reactions that can and do take place during acid treatment. Although no attempt has been made to present a complete literature survey, a bibliography of eighty-four references is included.

The action of sulphuric acid on hydrocarbons, sulphur compounds, nitrogen compounds, and oxygen compounds, and the effects of treatment conditions are discussed. Over 100 possible reactions during acid treatment of gasolines are tabulated.

R. W. G.

1042. Sweetening and desulfurization of light petroleum products. Part I—Introduction. V. A. Kalichevsky. *Refiner*, 1950, **29** (11), 97–100.—This is the introductory article of a study of the chemistry and treating procedures employed by refineries in the production of gasoline and other distillate fractions. The increased amount of high-sulphur-content crude being processed by the industry has led to much interest in its effects and removal in distillates. The old max sulphur figure for gasoline of 0·1% is out-dated, and gasoline with sulphur content of 0·5% and higher has been used without harmful effects.

The source and history of sulphur during refining is considered, special reference being made to cracking. A high degree of cracking leads to relative freedom from sulphur, but mild conditions (*e.g.*, vis breaking) have the opposite result. The various forms of sulphur which may be present are considered and briefly discussed. They include elemental sulphur, hydrogen sulphide, mercaptans, sulphides, disulphides, polysulphides, thiophenes, and thiophans. Twenty-seven literature references are given. R. W. G.

1043. Production of sulfur from hydrogen sulfide. M. Webb. *Oil Gas J.*, 11.1.51, **49** (56), 71.—The sulphur-recovery unit in operation at the Elk Basin, Wyoming plant of Stanolind Co. is described and a flow sheet given.

A modified Claus process yields 80 tons/day of 99·5% purity sulphur from hydrogen sulphide derived from a Girdler mono-ethanolamine sweetening unit. G. A. C.

Special Processes

1044. Britain gets " sootless " carbon-black plant. V. S. Swaminathan. *Oil Gas J.*, 11.1.51, **49** (36), 75.—Cabot Carbon Co. Ltd. are operating an American-owned carbon-black plant at Stanlow, Cheshire, designed for a maximum daily output of 60,000 lb of " Vulcan 3 " carbon black. Annual production will total between 8000 and 10,000 tons.

The modified furnace employs liquid residues to produce carbon black, and is operated 24 hr a day, as the process requires a very high temp (exceeding 2500° F).

At present 30,000 to 40,000 tons of Baton Rouge, U.S.A., petroleum-refinery residues form the raw material; but it is hoped that residues from British refineries will become available. The materials-handling operations are highly mechanized, the dried pellets being lifted by bucket elevator and transported to storage and package depot enjoying road and rail facilities. Flow sheets are provided. G. A. C.

1045. Stream pollution. M. Nord. *Chem. Ind.*, Dec. 1950, **67** (6), 893.—Stream pollution can be divided into three types, namely, physical or that which causes undesirable chemical or biochemical effects, chemical, where any organic material is present which can be oxidized biochemically through the agencies of dissolved oxygen and bacteria in the stream, and bacterial, which refers to the presence of pathological bacteria.

Disposal of liquid wastes is usually effected by dilution in a flowing stream, in which case it is essential that precautions should be taken so that the required degree of dilution will be achieved as rapidly as possible. Other methods available are surface and sub-surface irrigation, the latter being the method used most frequently by the petroleum industry. If the waste requires treatment before disposal its nature dictates the treatment to which it is subjected. Mechanical separation involves filtration and settling. Hydraulic separation entails settling, sedimentation, oil skimming, and flotation. In chemical coagulation flocculant precipitates of ferric and aluminium salts are used to either enmesh suspended solids or to produce high-valence ions which will neutralize charges on colloidal particles and allow coagulation to take place. In the category of chemical and physical reaction fall aeration, precipitation, and neutralization, while in disinfection the most commonly used reagent is chlorine. In addition to mechanical, hydraulic, and disinfection treatment, it is sometimes necessary to subject the waste to biological reaction, which involves either passing the waste through a stationary bed containing essential biological organisms or mixing it with the organisms as in the activated-sludge process. If this course is taken, complete removal of suspended, colloidal, and dissolved matter results. O. M.

1046. Use of filter beds. J. A. Pickard. *Chem. Prod.*, Jan. 1951, **14** (1), 4.—Filtration, as distinct from straining, makes use of both mechanical action and surface action. It has been shown by experiment that, for a given thickness of filter-bed, efficiency of filtration is inversely proportional to the size of the particle with which the filter-bed is constructed. In the author's opinion, an edge filter, which can be obtained in any metal, is the most satisfactory type of support for filter-beds. A further advantage of filter-beds is the possibility of preparing them in such a manner that they will have

special surface-active properties for specific applications. In this connexion, an example is the use of a mixture of manganese peroxide with kieselguhr to make palatable water heavily contaminated with iron and manganese, even though the passage of the water through the filter-bed is rapid. A further interesting application is the removal and destruction of bacteria by passing the medium in which they are growing through a filter-bed coated with silver. O. M.

1047. Patents. P. M. Arnold, assr to Phillips Petroleum Co. U.S.P. 2,512,596, 27.6.50. A process for producing alkenyl thiophenes where a 2-alkyl thiophene is reacted with formaldehyde at a temp of from 200° to 800° F and in the presence of an acid catalyst.

C. J. Helmers and P. H. Johnson, assrs to Phillips Petroleum Co. U.S.P. 2,513,022, 27.6.50. The process of producing hydrogen by the conversion of hydrocarbons and steam and using a catalyst which is favourable to carbonization in one stage and the formation of CO_2 and H in another stage, forming a hydrogen–carbon dioxide effluent, and recovering hydrogen from the effluent.

C. H. Holder, assr to Standard Oil Development Co. U.S.P. 2,514,282, 4.7.50. Describes a continuous method for preparing pure carbon monoxide by charging carbon dioxide to a fluidized mass of a reduced VI group heavy metal oxide and contacting at elevated temperatures.

S. D. Sumerford, assr to Standard Oil Development Co. U.S.P. 2,514,299, 4.7.50. A process for the production of aliphatic mercaptans by heating mixed aliphatic straight-chain, primary, monohydric alcohols, elemental sulphur, and hydrogen in the presence of a TiO_2 catalyst at temp of 400° to 700° F, and pressures 500 to 2,000 p.s.i.

K. C. Laughlin, assr to Standard Oil Development Co. U.S.P. 2,514,300 4.7.50. A process for the preparation of aliphatic mercaptans by heating a mixture of aliphatic straight-chain, primary, monohydric alcohols, hydrogen sulphide, and hydrogen in the presence of a TiO_2 catalyst at a temp of 300° to 800° F, and pressures 200 to 2,000 p.s.i. C. F. S.

Metering and Control

1048. Apparatus to deliver liquid at constant rate. J. H. E. Herbst. *Canad. J. Res.*, 1950, **28B**, 752.—An apparatus is described which delivers liquids at a constant predetermined rate and which is capable of operating overnight without attention. It has been found useful in various washing operations and in diasysis. A. D.

1049. Practical aspects of orifice meter calculations. H. A. Jacobson. *World Oil*, Jan. 1950, **130** (1), 177–82. (*Condensation of paper read at Semi-Annual Mtng A.S.M.E.*) —Orifice-meter calculations are troublesome to the practical engineer, due to lack of simple, clear information. The subject is reviewed, and practical methods of obtaining coefficients, etc., are discussed. A. H.

1050. Pure air for pneumatically-operated instruments. Anon. *Mech. World*, 23.2.51, **129** (3345), 167.—Water, dust, and possibly oil often pollute compressed air. Of these moisture is the most important, the amount present depending on the humidity of the atmosphere. At a temp of 65° F and a relative humidity of 100% there would be 0·016 pint of water in each 100 cu. ft. of free air. A large portion of this will be deposited somewhere in the system, and with dirt and oil might form emulsions which will cause trouble in the instruments in spite of fitting local filters. Since more moisture is deposited the lower the temp to which the air is cooled, it is desirable to cool the air as much as possible before passing it to the pipes. The paper puts forward an installation for supplying 95% dry air. Air from the compressor is first passed through an oil filter to remove as much free oil as possible. It is then passed to a water-cooled aftercooler and on to a separator, where a large proportion of the impurities are removed. The compressed air then passes to a receiver and from there to absorbers containing aluminium or silica gel, where the humidity of the air is reduced to about 5%. This figure is far below that likely to cause trouble, but considering the financial loss which can be incurred if pneumatic instruments become faulty, the extra cost of producing

really dry air is considered to be a sound investment in view of the security it gives. A diaphragm compressor is described which has been specially designed to provide air completely free from oil and other impurities. A. S.

1051. Remote tank caging at Shell's Bakersfield station. D. H. Stormont. *Oil Gas J.*, 1.2.51, **49** (39), 62.—The remote gauging system at Bakersfield, Calif., employs an electronically regulated direct-current voltage of constant output to power electronic gauger transmitters located at each of eight 68,000-brl tanks.

It provides operation information at all times, obviates necessity of tank-farm gauger making rounds on foot, except for sampling, etc., and enables pump man to determine for himself rates and vol of oils he is handling. G. A. C.

1052. Results in experiments with pulsation eliminators. D. J. Masson. *World Oil*, June 1950, **130** (7), 264. (*Condensed from a paper presented before the ninth Annual Applachian Gas Measurement Short Course.*)—The errors in meter readings caused by pulsations in gases due to compressors, etc., are discussed. A "pulsometer" and preliminary experiments on eliminators are described. Earlier tests have shown that errors can be decreased by increasing the differential pressure across the orifice meter. A. H.

1053. Centrifugal pumps for refinery service. Anon. *Petroleum*, Sept. 1949, **12** (9), 231–2.—Describes some of the pump types used in modern oil refineries, including descriptions of the Worthington-Simpson heavy type single-stage and two-stage pumps which have been produced in close co-operation with oil companies. Temp up to 850° F and working pressures up to 750 p.s.i. are catered for with capacities up to 1000–1200 I.G/min.

Pumps used at the Stanlow refinery are described. To deal with all aspects of refinery pumping, three basic designs were selected: a single stage pump, a two-stage pump, and a multi-stage barrel-pump. Steps were taken to keep variations of parts to a min to help solve the considerable maintenance problem, the same internal parts being used in all three groups. Particular attention is paid to reduce leakage to a min.

"Autometric" pumps designed to deal with a variety of liquids and duties are also briefly described. R. E. P.

1054. Design and development of pumps for the development laboratory. R. C. Brain, J. W. Hyde, and R. O. Judd. *Petroleum*, Sept. 1949, **12** (9), 219–23.—Pumps are described which have been specially designed to fulfil duties which could not be met by any readily available commercial pump. These units were developed to meet an urgent demand, and design was strongly governed by availability of materials. Particular emphasis is placed on constancy of delivery and valve design.

Includes: (1) A gas-recycle booster to circulate hydrogen at elevated pressures for lubricating work on catalytic processes, where no losses can be tolerated.

(2) An immersed pump developed to deliver 1 to 3 litres/hr of heavy residue at 3000 p.s.i. pressure.

(3) A duel proportionating pump unit modified to pump 3 litres/hr of liquid propylene and fatty acids at a discharge pressure of 3000 p.s.i.

(4) A rubber-tube squeeze pump designed for pumping small quantities of highly corrosive liquids at atmospheric pressure; also used as an air compressor.

(5) Electrolytic displacement pumps suitable for feeding rates of 1 cc to 50 cc/hr.

A description is also included of an automatic column head to measure off-take rate. R. E. P.

1055. Pumping high-viscosity liquids with centrifugal pumps. W. F. Riester. *Petroleum*, Sept. 1949, **12** (9), 224–5.—Although it is fairly certain that the accepted design—practice for water is unsatisfactory for viscous oils, it is shown that the centrifugal pump for viscous liquids has not yet been designed. Basic features are discussed which may assist the oil engineer to evaluate a centrifugal pump when handling viscous oil. Thus for a given head and capacity: (*a*) high speed is preferable to low speed; (*b*) small-dia impellers are better than large ones; (*c*) a two-stage back-to-back impeller pump would be preferable to a single-stage pump at the same speed; (*d*) open impellers

have less friction than closed impellers; (*e*) diffusors are usually an improvement over volutes; (*f*) mixed flow is more efficient than radial flow as there is less wall and passage friction—Francis vanes are better than radial vanes; (*g*) multi-staging has advantages over single staging; (*h*) large clearances are permissible, reducing friction losses without increasing leakage losses, and (*i*) fewer vanes per impeller create less friction. R. E. P.

PRODUCTS

Chemistry and Physics

1056. Effect of reservoir rock on vapour-liquid equilibrium. C. F. Weinaug. *World Oil*, May 1950, **130** (6), 175.—Calhoun and others, in a recent paper showed that the vapour pressure of a liquid contained in a porous solid is lowered in the presence of the sand or porous media. Weinaug and Cordell similarly indicated that the P.V.T. vapour–liquid equilibrium values are not affected by sand. It is shown that this apparent disagreement is explained away by the fact that the average diameter of the sand grains used by Calhoun were about $\frac{1}{3}$ the diameter of those used by Weinaug. The smaller capillaries caused smaller curvature radii of liquid surfaces which according to well-known relationships cause lower vapour pressures. The theory is developed that, in an actual reservoir, water fills the smaller interstices and thus the vapour–liquid equilibrium relationships of the hydrocarbons in condensate fields would not be significantly different to the normal laboratory determinations. A. H.

1057. The hydrolysis of acetic anhydride in water and in the system water : methyl ethyl ketone. E. N. Banks, A. E. Marshall, R. W. Vollett, and R. R. McLaughlin. *Canad. J. Res.*, 1950, **28B**, 663.—The rate of hydrolysis has been measured for acetic anhydride at 25°C in water (A), in solutions of methyl ethyl ketone (M.E.K.) in water (B), and in solutions of water in M.E.K. (C). In A the linear relation observed before between velocity constant and initial concentration of acetic anhydride has been confirmed, it being noted that for any initial concentration of acetic anhydride reaction was pseudo-monomolecular. This occurs again in B, but velocity constant is lower than in A and shows a linear decrease for increasing concentration of M.E.K. The second-order rate must be modified in C to compensate for the pressured catalytic effect of the hydrogen ion produced by hydrolysis. An equation is given relating velocity constant and initial concentration of water, M.E.K., and acetic anhydride in case B. A. D.

1058. Mass spectra of the deuteromethanes. V. H. Dibeler and F. L. Mohler. *Bur. Stand. J. Res., Wash.*, 1950, **45** (6), 441.—The four deuteromethanes have been synthesized and their mass spectra measured and discussed. J. T.

1059. The mechanism of oxymercuration of alkenes. A. G. Brook and G. F. Wright, *Canad. J. Res.*, 1950, **28B**, 623.—Mercuric acetate can be effectively added to *cyclo*hexene in methanolic mercuric acetate to give 1-methoxy 2-acetoxy mercury *cyclo*hexane, but 1-acetoxy-2-acetoxy mercuri*cyclo*hexane cannot be an intermediate as rate at which this latter compound is converted into the product is much too slow to account for the rate of methoxy mercuration. Ionic mechanisms have also been shown to be untenable, but a co-ordinative dipole mechanism is suggested which explains the complete retention of configuration during addition as well as the function of boron trifluoride as an accelerator in this reaction. A. D.

1060. Liquids whose viscosity is independent of temperature. G. H. Göttner. *Erdöl u. Kohle*, 1950, **3**, 598–606.—Examples are quoted of liquids showing anomalous visc/temp effects, such as liquid He, liquid S, liquid crystals, colloidal solutions. Most of these are, however, either effective at temp outside the usual technical ranges or are corrosive. Hitherto only two liquids showing such effects have been known which could be of practical value, aq solutions of alkylphenolpolyglycol ethers and glycerol/dioxan mixtures. Results are given of tests on solutions of poly*iso*butylene (mol. wt.

100,000) in benzene; at concn in range ¼ to 1¼% and for temp 25° to 60° C temp has very little influence on visc of such solutions. Detailed results are given for a 1·07% solution (visc approx 5 cs), this shows structure-formation (*i.e.*, non-Newtonian flow) to a slight extent. Theoretical explanations applicable to previously reported liquids whose visc is independent of temp are reviewed, these do not, however, apply to solutions of poly*iso*butylene in benzene; it is suggested that behaviour of latter is linked with elastic (rubber-like) properties of poly*iso*butylene. On lowering of temp, vol of dissolved mol decreases due to aggregation, marked orientation of the mol chains does not, however, occur. Application of the views developed to the mode of action of V.I. improvers is discussed, and principles are outlined on which preparation of liquids whose visc is independent of temp can be based. V. B.

1061. The effect of an electric field on the viscosity of liquids. II. E. N. da C. Andrade and C. Dodd. *Proc. Roy. Soc., S. A*, 9.1.51, **204** (1079), 449.—Part I of the paper (1946) recorded experiments on the influence of a constant electric field on the visc of liquids, and showed that a considerable increase in visc took place when polar liquids that transmitted a small current were subjected to high fields. There was no detectable effect with non-polar liquids or with polar liquids that were good insulators. It was found that the action of the field produced concentrations of free ions near the metallic surfaces between which the liquid flowed, and these ions acted as centres round which the polar molecules formed clusters.

In order to obtain the true effect of an electric field on the visc of liquids, measurements must be made with alternating fields whose frequency lies within a certain range. In this paper apparatus and methods are described with which comparative viscosities can be consistently measured, with and without field, to within a few parts in a million. Experiments are described which have shown that with three polar liquids there is a small increase of visc proportional to the square of the field. It has also been shown with a high degree of precision that there is no such effect with the non-polar liquid benzene. It is shown in a theoretical discussion that electrostriction cannot be responsible for the effect. Five literature references are given. U. M.

1062. Use of coaxial-cylinder viscometers and capillary-tube viscometers for suspensions. F. G. Eveson, R. L. Whitmore, and S. G. Ward. *Nature*, 1950, **166**, 1074.—The apparent visc of a suspension of solid particles in a liquid, measured with a capillary-tube viscometer, increases as the bore of the capillary is increased. Two theories have been advanced to account for this Sigma effect, and both lead to the conclusion that it should also be observed in a coaxial-cylinder-type viscometer.

Visc measurements have been made on stable suspensions of methyl methacrylate polymer at concentrations up to 20% in aqueous $Pb(NO_3)_2$ and glycerol, using a Couette-type viscometer with annular gaps of 2, 3, and 4 mm. The size of the particles varied from 38 to 388μ. In all cases the visc was independent of the rate of shear, and no Sigma effect was detected.

It may be concluded that coaxial-cylinder viscometers are to be preferred to those of the capillary tube type for visc measurements on stable suspensions. H. C. E.

Analysis and Testing

1063. Determination of aromatics and olefins in wide boiling petroleum fractions. A. E. Spakowski, A. Evans, and R. R. Hibbard. *Anal. Chem.*, 1950, **22**, 1419–22.—A method is described for the analysis of wide-boiling petroleum fractions with end points below 600° F. Chromatography is used to split the sample into four fractions: non-aromatic, intermediate, pure aromatic, and a pure aromatic "wash." The per cent aromatics in the intermediate fraction is determined by specific dispersion, and the total aromatics in the sample is the sum of those found in the intermediate and final two fractions. Total olefins plus aromatics are determined by sulphonation and olefins by difference. Accuracies of 1% are attained with analysis times of less than 8 hr. J. S.

1064. Determination of copper and iron in oils by amperometric titration. T. D Parks and L. Lykken. *Anal. Chem.*, 1950, **22**, 1503–5.—A method is described for the determination of copper and iron in inorganic residues, such as that obtained from oils, by

reduction in a silver reductor and amperometric titration with dichromate ion at a rotating-platinum electrode. When copper is determined in the absence of iron, the reduced solution is received under ferric alum solution and the equivalent amount of ferrous iron produced is titrated. When both iron and copper are being determined, the reducing value of the mixture is determined on an aliquot of the reduced solution received under ferric alum, the iron is determined by titrating a separate aliquot after selective oxidation of the copper by aeration, and the copper is calculated by difference. The titration procedure is rapid, precise, and accurate; it is sensitive to 0·02 mg of iron or copper. The method is particularly suitable for the analysis of copper and iron in lubricating oils, because other elements that are normally present in these oils do not interfere. J. S.

1065. Determination of impurity traces. Mass spectrometric method. R. E. Honig. *Anal. Chem.*, 1950, **22**, 1474–6.—A method for the mass spectrometric determination of impurity traces in described which is applicable to cases where the impurity pattern is masked by the main compound. It utilizes ionizing energies in the ionization and appearance potential range. Results are presented for some deuterated hydrocarbons and for 2-methyl propane (*iso*butane). J. S.

1066. Determination of small amounts of silver in lubricating oils by amperometric and gravimetric methods. T. D. Parks and L. Lykken. *Anal. Chem.*, 1950, **22**, 1505–7.—Methods are described for the determination of silver in new and used lubricating oils, which may also contain aluminium, barium, cadmium, calcium, copper, iron, lead, magnesium, tin, zinc, and the alkali metals as well as sulphur, phosphorus, chlorine, and bromine. After ignition of the oil and solution of the silver in the inorganic residue, the silver is determined with potassium iodide by either amperometric titration or semimicro-gravimetric precipitation. Both methods give results which are accurate to 1% in the concentrations encountered, but the amperometric method is more sensitive and more rapid than the gravimetric method. J. S.

1067. Flame photometer techniques. Determining typical additives in petroleum oils. A. L. Conrad and W. C. Johnson. *Anal. Chem.*, 1950, **22**, 1530–3.—A flame-photometer method for determining alkali and alkaline-earth elements in inhibited lubricating oils is described which permits atomization of samples in organic media. This greatly reduced the time required for sample preparation, and eliminates many possible causes of contamination. Working in low concentration ranges permits samples to be diluted to the point where visc effects become uniform. Analysis of typical lubricating oils show reproducibility of the method. Techniques for improving accuracy are included, and information is given concerning expected interferences. J. S.

1068. Evaluation of crude oil. Evaluation Panel of I.P. Standardization Sub-committee No. 2—Crude Oil. *J. Inst. Petrol.*, 1950, **36**, 693–704.—It is possible by methods such as I.P. 24 to detect major differences between crude oils, but experience has shown that such methods are inadequate for complete crude-oil evaluation. The principles outlined by the Panel are intended to enable an evaluation to be made from which the yields and qualities of potential products may be derived. A. R. W. B.

1069. High frequency titrations. Mercurimetric determination of chloride. W. J. Blaedel and H. V. Malmstadt. *Anal. Chem.*, 1950, **22**, 1410–12.—Chloride can be determined in acidic solution by direct titration with 0·01*M*-mercuric nitrate using the high-frequency titrimeter with a precision corresponding to about 0·03 ml of mercuric nitrate. The end-point agrees well with the equivalence point over a considerable range of conditions, allowing a simpler procedure than is possible when chemical indicators are used to establish the end-point. For this titration, the high-frequency titrimeter appears superior to potentiometric or conductometric methods for establishing the end-point. J. S.

1070. Infra-red determination of ortho and meta isomers in *p*-cresol freezing points of pure cresols. O. E. Knapp, H. S. Moe, and R. B. Bernstein. *Anal. Chem.*, 1950, **22**, 1408–10.—An infra-red spectrophotometric procedure for the determination of low concentrations of *o*- and *m*-cresol in *p*-cresol is described. The absorption bands at

13·37 and 12·92μ characteristic of the *ortho* and *meta* isomers are used for the determination. With a 0·027-mm absorption cell, the accuracy of the analyses was ±0·3% *o*- and ±0·5% *m*-cresol. An account of the method of preparation and purification of the three isomers is given. Freezing-point data for the pure compounds are given. J. S.

1071. Oxidation stability of transformer oils. A. J. Ham and C. N. Thompson. *J. Inst. Petrol*, 1950, **36**, 673–83.—Published methods for the evaluation of oxidation stability are reviewed briefly and some of their inadequacies pointed out. The authors are developing a graded series of oxidation test procedures which are described. The first two are oxygen absorption tests, the second differing from the first in that a less-active catalyst is used and the more volatile oxidation products are removed. In the third a small transformer unit is lagged and run at approx 20% overload, and in the fourth a larger transformer is run under slighter overload conditions. Some results are discussed, and it is pointed out that the advantage of this graded series of oxidations is that information can be obtained concerning the onset and course of oxidation in the slower field tests by subjecting small samples from these to one or other of the more rapid oxygen-absorption tests. A. R. W. B.

1072. Photometric determination of phenols. Application to blending of new lubricating oils. R. E. Snyder and R. O. Clark. *Anal. Chem.*, 1950, **22**, 1428–31.—The use of phenolic compounds as addition agents in lubricating oils for inhibition of oxidation is widespread throughout the petroleum industry. Existing photometric methods for the determination of phenols have utilized an extraction procedure prior to the development of colour. In the proposed test the oil is treated directly with an *n*-amyl alcohol solution of phosphomolybdic acid, and the "molybdenum blue" complex is developed and extracted simultaneously with an ammoniacal solution of ethylene glycol–amyl alcohol. This colorimetric reaction has been applied successfully for the quantitative estimation of numerous phenols in the blending of lubricating-oil stocks, with a mean error of ±5%. Attention is directed to limitations of the method as a control in the compounding of new lubricating oils, and the wide variance in the sensitivity of response of phenols as a function of constitution and structure. Additional factors are discussed that affect the formation and stability of the colour and the overall performance of the method. J. S.

1073. Role of extraction in analytical chemistry. G. H. Morrison. *Anal. Chem.*, 1950, **22**, 1388–93.—Analytical liquid–liquid extractions fall largely into three classes: inorganic, organometallic, and organic. Laboratory apparatus and general techniques, including batch and continuous procedure, are reviewed. Many inorganic extractions are dependent upon the formation of undissociated complex acids which are soluble in organic solvents. The salting-out effect produced by the presence of cations plays an important role in extraction; in general, the cations of higher valency are more effective. Several simplified theoretical relationships concerning organo-metallic extractions are presented which emphasize the importance of pH and concentration of reagent in metal extraction. Improved countercurrent distribution instruments permit separation or estimation of closely related organic substances, and are applicable to many complex organic or biochemical problems. J. S.

1074. Stream analyses locate oil field pollution sources. O. S. Jones. *World Oil*, Feb. 1950, **130** (2), 148–50.—To avoid pollution of fresh water by brine from oil wells, oil companies in southeastern Kansas have seen fit to run their own systematic stream samples. A field-sampling kit consists of standard $AgNO_3$ solution and a potassium chromate indicator. It is wise practice to sample fresh water in such areas in case contamination existed before operations were commenced. A. H.

1075. Test for active sulphur in fuels, solvents, etc. Anon. *Erdöl u. Kohle*, 1950, **5**, 612–13.—Draft German standard methods for detection of corrosive S in engine fuels (DIN 51759) and pet solvents (DIN 51760). Cu strip procedure is used, 3 hr at 100° C for fuels, ½ hr at b.p. for solvents. Prior to test samples are tested for presence of peroxides by agitation with KI–starch solution and, if found, these are removed by ferrous sulphate. V. B.

1076. Theory and practice of analytical distillation. A. Rose. *Anal. Chem.*, 1950, **22**, 1369–71.—A small amount of theory and a great deal of empirical practice form the basis for the very considerable achievements of analytical distillations to date. It is probable that the practical limits are being approached, unless there are additional theoretical contributions. These will probably be based on an extension of the Raleigh equation, with numerical solutions obtained by means of automatic high-speed computing machines. An interim procedure is given for estimating theoretical plates, reflux ratio, charge size, column size, and time required in analytical distillation.

J. S.

1077. Application of certain instrumental methods in production research. T. W. Dennis and J. M. Hunt. *World Oil*, July 1949, **129** (3), 152.—A brief introduction to the methods of analysis of oil deposits and sedimentary rocks; the infra-red spectrophotometer, for the examination of organic compounds; X-ray diffraction, for crystalline substances; and the differential thermal analyser, for clays.

References. A. J. H.

1078. A maximum pressure indicator. Anon. *Auto Engr*, Feb. 1951, **41** (2), 79.—A new instrument is described with which max and compression pressures of internal-combustion engines can be measured. It is known as the Dobbie McInnes peak-pressure indicator, and is being manufactured under licence from the inventors, Sulzer Brothers Ltd. A diagram and full description explain the method of operation of this indicator, which was primarily evolved for use on medium- and high-speed internal-combustion engines. It shows immediately whether there is unequal loading of the cyl due to leaking piston-rings and valves and, in the case of diesel engines, due to unequal metering of fuel, choked atomizers. Advantages claimed for this piece of apparatus are: (*a*) it is automatic; (*b*) infrequent cleaning required; (*c*) accuracy not dependent on personal judgment; (*d*) true static calibration; (*e*) rapid operation; (*f*) no pistons, valves, or gear or ratchet mechanisms; (*g*) negligible friction; (*h*) low cost.

A. S.

Crude Oil

1079. The crude oil of Sudr, Egypt. I. Youssef. *J. Inst. Petrol.*, 1950, **36**, 684–92.—Data obtained in the evaluation of Sudr crude are presented and a proposed refining scheme outlined. From the lab distillation a wt yield of 6·7% gasoline of 45 O.N.; 14·3% kerosine; 15·2% gas oil (Diesel Index 55·9); 27% wax distillates (three fractions), and 35% bitumen was obtained. A. R. W. B.

Gas

1080. Purification and dehydration of gases. C. L. Blohm and W. F. Chapin. *World Oil*, June 1950, **130** (7), 253–62.—The various methods of purifying natural and other gases are reviewed, together with references to the original papers. The amine processes are then discussed in full and comparisons made of the monethanolamine, diethanolamine, aqueous and glycol-amine, single and split-stream processes. A. H.

1081. Patents. S. H. White. U.S.P. 2,513,767, 4.7.50. A gaseous fuel mixture having high cal. val. and low ignition point, using city gas and petroleum ether boiling over the range 40° to 60° C.

S. H. White. U.S.P. 2,513,768, 4.7.50. A gaseous fuel mixture of high cal. val. and low ignition point, using propane and petroleum ether.

S. H. White. U.S.P. 2,513,769, 4.7.50. A gaseous fuel mixture of high cal. val. and low ignition point using city gas, propane, and petroleum ether.

S. H. White. U.S.P. 2,513,770, 4.7.50. A gaseous fuel mixture of high cal. val. and low ignition point, using city gas, propane, and a mixture of petroleum ether and ethyl ether.

D. D. Davidson, assr to Shell Development Co. U.S.P. 2,513,994, 4.7.50. A cyclic process for the production of synthesis gas by reacting methane and a metal oxide is improved by effecting the reaction with an alkali-metal oxide catalyser at between about 1850° and 2300° F.

W. H. Rupp, assrs to Standard Oil Development Co. U.S.P. 2,514,340, 4.7.50. Process for the production of gases rich in hydrogen by reacting CO with H_2 in a synthesis zone using a synthesis catalyst. C. F. S.

Engine Fuels

1082. Boiler fuel for motor ships. Anon. *Motor Ship*, Jan. 1951, **31** (370), 287.—Prices of bunker boiler oil and diesel oil are compared, and it is shown that use of boiler oil in the diesel engines of motor ships effects a saving of between 20 and 35% on fuel cost at current prices. The additional cost of installation of equipment necessary for operation on boiler oil must be taken into account, but upkeep charges appear to be no higher than those for engines run on diesel fuel. There are nearly 200 ships either already operating on boiler oil or for which the necessary provision is made. Technical problems involved in using boiler oil are not discussed, but future trends in availability and price differential of boiler oil and diesel oil respectively, and future quality of boiler oil, are reviewed. Fourteen literature references are given. U. M.

1083. Tests of Stork engines on boiler oil. Anon. *Motor Ship*, Jan. 1951, **31** (370), 314.—Satisfactory trials carried out at Stork Bros. works in Holland are reported on standard double- and single-acting two-stroke Stork engines, to ascertain their performance when running on boiler oil. The double-acting engine was a six-cyl unit with cyl of dia 720 mm, a piston stroke of 1200 mm, and output of 6500 b.h.p. at 116 r.p.m. Ordoil was used as fuel; it was purified in the normal way in a purifier and clarifier arranged in series, and temp was maintained at 90° C. The fuel-pump blocks for top and bottom cyl respectively were provided with an additional connexion to the suction spaces of these pumps, enabling Ordoil to circulate through the blocks. Insulated copper steam pipelines were placed alongside fuel pipes, in order to maintain heat of fuel up to fuel valves. The oil was passed through a double felt filter before being supplied to engine. Results of tests are tabulated, and specifications of the two grades of Ordoil used are listed. At first some difficulty was encountered from formation of carbon deposit on bottom fuel valves, but this was overcome by modifying the dia of the high-pressure bottom fuel pipelines and by more intensive cooling of atomizers. Throughout trials combustion was excellent and the exhaust was clean. Consumption with Ordoil corresponded with that on diesel oil, allowing for the lower cal. val. U. M.

1084. The use of residues as diesel fuels. H. S. Humphreys. *Motor Ship*, Oct./Nov./Dec. 1950, **31** (369), 235.—A full report is given of the sea performance of two of the British Tanker Co's vessels, equipped with Doxford and with Harland-B. & W. four-stroke engines respectively, when running on furnace oil. Essential requirements for converting a marine main diesel installation to run satisfactorily on furnace oil are: (1) the provision of additional fuel-heating arrangements throughout the system in order to reduce the visc to the required degree to permit efficient centrifuging and obviate sluggish operation, and (2) the introduction of a centrifugal clarifier working in series with a separator in order to obtain the highest possible degree of purity before the fuel enters the main engine system.

The arrangements of the fuel systems in the two vessels are described and illustrated by diagrams. The shop trials were carried out on Haifa heavy fuel, of visc 1360 sec Red I at 100° F, preheated to 170 F° before purifying and clarifying. Analysis of the fuel before and after purifying and clarifying respectively showed no appreciable change. Furnace oil bunkers with a max visc of 1200 sec Red I at 100° F will be used in service, because of the difficulty of obtaining Haifa heavy fuel at the ports where these ships will trade. Detailed accounts are given of the state of the main engines of both ships when they were opened out for examination and overhaul. U. M.

1085. Patents. W. A. Partridge and H. J. Alty, assrs to Anglo-Iranian Oil Co. Ltd. U.S.P. 2,513,669, 4.7.50. A stabilized gasoline containing T.E.L. for use in I.C. engines, containing also a lead salt of a fatty acid as stabilizing agent.

A. Wachter and N. Stillman, assrs to Shell Development Co. U.S.P. 2,514,018, 4.7.50. A gasoline comprising a leaded mixture and from about 0·001 to about 1% by weight of an *N*-nitroso di(aliphatic hydrocarbon) secondary amine. C. F. S.

Lubricants

1086. Grinding fluids. H. W. Wagner. *Mech. Engng*, Feb. 1951, **73** (2), 128.—The two important functions of grinding fluids are lubrication and cooling. A classification is given of the various types of grinding fluids, including air, water, emulsions, kerosine, straight mineral oils, and grinding oils. Their functions are listed, and of these lubrication, cooling, and rust prevention are the most important. The fluids included in the classification are rated from the point of view of lubrication, cooling, and average of desirable negative functions. The latter are defined as those which reduce or minimize undesired conditions not present in dry grinding, but which may appear only because a liquid is used. Notes are given on the applications to these fluids, and an indication supplied of the factors to be considered when selecting a fluid for a particular type of work. The question of lubrication is discussed, and it is concluded that lubrication in grinding is the act of keeping the wheelface sharp by combating both loading and attritious wear of the abrasive points. As far as surface finish is concerned, it is stated that the fluid which provides more effective lubrication retards the undesired changes and maintains the desired finish for a longer time. Experimental evidence is offered in support of the statements made in the paper. In general, among the fluids in common use, grinding oils provide max lubrication, and water provides max cooling. Oils are more costly, and there are more problems connected with their use than water-compound mixtures. In some grinding operations, however, oils are essential and more economical. A. S.

1087. New production plant for oil additives. Anon. *Gas Oil Pwr*, 1950, **45**, 320.—A brief survey of the history of motor-oil additives. Beginning with the use of sodium oleate and aluminium naphthenate as detergent additives, the introduction of calcium phenyl stearate and calcium dichloro-stearate is mentioned. Since soaps have pro-oxidant and corrosive properties, these compounds were withdrawn, and in 1939 an oil containing calcium cetylphenate as detergent and calcium alkyl phosphite as oxidation inhibitor was introduced. Paranox 56 became available in 1940.

The new plant at Fawley will manufacture Paranox 56, which is a compound containing barium and sulphur. H. C. E.

1088. Patents. D. E. Adelson, assr to Shell Development Co. U.S.P. 2,512,784, 27.6.50. A lubricant comprising mineral lubricating oil and a small amount of a stable, non-corrosive organic reaction product which is obtained by reacting at about room temp and 100° C, ammonium hydrosulphide–hydrogen sulphide with an oxygen-containing compound until about 4 to 26·4% sulphur enters the reaction product.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,513,060, 27.6.50. The preparation of lubricants containing organic oxidized and sulphurized esters.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,513,061, 27.6.50. A process for preparing antioxidants for mineral oil lubricants by heating 1 to 4 mol of benzaldehyde, 1 to 4 mol *n*-dimethylaniline, and 0·5 to 4 mol of formaldehyde per mol of benzaldehyde with an activated-clay catalyst at a temp not over 350° F.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,513,062, 27.6.50. A process of preparing antioxidants for mineral oil lubricants by heating diethylaminobenzaldehyde with from 1 to 4 mol of *n*-dimethylaniline and 1 to 4 mol of formaldehyde per mol of diethylaminobenzaldehyde with an activated clay catalyst at a temp not over 350° F.

H. G. Smith, T. L. Cantrell, and J. G. Peters, assrs to Gulf Oil Corpn. U.S.P. 2,513,063, 27.6.50. A process of preparing antioxidants for mineral oil lubricants by heating from 1 to 2 mol of dimethoxybenzaldehyde, 2 to 8 mol of *n*-dimethylaniline, and 2 to 8 mol of formaldehyde with an activated clay catalyst at a temp not over 350° F.

J. E. Schott and E. L. Armstrong, assrs to Socony Vacuum Oil Co. Inc. U.S.P. 2,513,680, 4.7.50. A lime-base grease made up of lubricating oil, lime soaps, a calcium salt of a monocarboxylic fatty acid, and a small percentage of a lime salt of phosphoric acid.

A. Wachter and N. Stillmann, assrs to Shell Development Co. U.S.P. 2,514,017, 4.7.50. A lubricant comprising mostly mineral lubricating oil and from about 0·001% to about 5% by weight of a compound having the formula

$$\begin{matrix} R_1 \\ R_2 \end{matrix} \!\!> N\text{–}N{=}O$$

A. J. Morway, assr to Standard Oil Development Co. U.S.P. 2,514,286, 4.7.50. A lubricating grease which is relatively liquid and mobile and which has the property of setting up to a solid grease consistency, comprising mineral lubricating oil containing a soap-salt thickener prepared by mixing one molar proportion of fatty acid to the C_{12} to C_{22} range, at least half molar proportion of C_2 to C_4 fatty acid, and an alkali metal hydroxide into the oil, heating and stirring to at least 450° F, then allowing to cool with stirring to a temp of about 200° to 550° F and then letting the composition cool without further working.

A. B. Small and R. M. Thomas, assrs to Standard Oil Development Co. U.S.P. 2,514,296, 4.7.50. A solvent-resistant low-temp lubricant consisting of 40 to 90% by weight of a polyhydric alcohol, 10 to 60% of zinc stearate, and 0·01 to 5% of a sulphonate-type wetting agent.

A. E. Calkins, R. Darley, and A. Beerbower, assrs to Standard Oil Development Co. U.S.P. 2,514,311, 4.7.50. A process of preparing aluminium-base grease by combining 62% by weight of unfinished Venezuelan distillate with 32% of finished Coastal oil and about 6% of aluminium soap.

A. J. Morway and R. O'Halloran, assrs to Standard Oil Development Co. U.S.P. 2,514,330, 4.7.50. A mixed-base lubricating grease consisting of mineral lubricating oil with a V.I. of at least 80 thickened with a sodium–barium soap of fatty acid.

A. J. Morway, assr to Standard Oil Development Co. U.S.P. 2,514,331, 4.7.50. A stabilized lubricating grease consisting of a mineral-base lubricant of great consistency and 2·8 to 40% of alkaline-earth metal soap. C. F. S.

Bitumen, Asphalt, and Tar

1089. An apparatus for measuring the permeability to water vapour of bituminous emulsion films. A. Evans and C. Q. Keiller. *J. Soc. chem. Ind.*, **69** (Sup. Iss. No. 1), S1–S3).—A sturdy self-contained apparatus is described. Water vapour diffuses through a bitumen film and is absorbed into a dessicant supported in a spring balance contained within the apparatus. By means of electrical contacts the balance is made sensitive to 1 mg. H. J. B.

1090. Softening solvent helps pulverize and remix old bituminous surfacing. E. Withycombe. *Rds & Streets*, Dec. 1950, **93** (12), 67.—The possibility of utilizing a softening material to save bitumen and to cut down on reclamation costs for roads has been examined by the Shell Oil Company. The softening material used is an aromatic oil. A section of asphaltic concrete laid in 1936 with 50/60 pen binder was reworked. This pavement, which had commenced to break up into small slabs, was chosen to try out the process because it was an extremely difficult pavement to break up. The penetration of the binder was found to be about 25. The asphaltic concrete was broken up in stages to produce material of the normal size for road-making, dust being eliminated during the process by the use of water. The asphalt softener was introduced through a Gardner mixer in two applications 24 hr apart at a total concentration of 0·8 to 0·9%. The stability of the road 48 hr after the application of the softener was found to be 5 to 7% compared with an initial value of 35%. R. H.

1091. The selection by petrographical methods of roadstone for use in rolled asphalt paving mixtures. L. G. C. Sims. *J. Soc. chem. Ind.*, **69** (Sup. Iss. No. 1), S18–S23. —In conjunction with BS 812, six main requirements for roadstone are set out, followed by a petrological interpretation, together with a suggested system of classification. Microphotographic illustrations are included. H. J. B.

1092. The volume flow of asphalt. M. Reiner, P. J. Rigden, and E. N. Thrower. *J. Soc. chem. Ind.*, Sept. 1950, **69** (9), 257–60.—A mathematical approach to the dimensional changes and progressive volume increase recorded on an artificially prepared " asphalt " subjected to a traction (*i.e.*, tension) of 100 p.s.i. In extension (the case here under review), dilatancy caused by the tractional shear forces plus Reiner's volume (or isotropic) flow act in the same direction to give volume increase. In compression these effects act in opposite directions, so that volume changes may be in either direction according to the predominating effect.

Details of the apparatus are given, together with a set of results. These are analysed on the theory that both the shear and volume flow have elastic (recoverable) and viscous (permanent) components in parallel.

These components are calculated, and the corresponding deformational and viscous Poisson ratios (*i.e.*, lateral change : longitudinal change) calculated. H. J. B.

Special Hydrocarbon Products

1093. 2,4-D eradicates water hyacinth. E. C. Greco. *Oil Gas J.*, 11.1.51, **49** (36), 85. —Complete destruction of water hyacinth on the inland waterways of South Louisiana is being accomplished at relatively little expense by pressure spraying dilute solutions of 2,4-D in water. 150 gal of a solution of 6 lb acid equivalent per acre gives good coverage.

The chemical method is much less expensive and more effective than mechanical means. G. A. C.

Miscellaneous Products

1094. The blistering of paint films. Part II. Blistering in the presence of corrosion J. E. O. Mayne. *J. Oil Col Chem Assoc.*, Dec. 1950, **33** (366), 538.—The contents of the blisters produced in a film of plasticized polystyrene, when applied to steel immersed in seawater and the passage of water through unsupported films of plasticized polystyrene were investigated. The materials used, method of production of blisters, and examination of the contents are described. After immersion of a specimen in seawater for forty-six days small rusty nodules were observed. These corresponded to weak points in the film which developed into anodic areas where iron compounds were formed ; their distribution bore no relation to the large blisters which are anodic areas. In osmotic experiments the following systems were examined : (*a*) distilled water/membrane/seawater ; (*b*) 1·3*N*-NaOH/membrane/seawater ; (*c*) distilled water/membrane/34% (by wt.) sugar solution. Experimental results obtained agree with the assumption that the movement of water is governed by the difference of vapour pressure of the solutions on each side of the membrane. With all three systems tested there was movement of water towards the negative electrode. The movement of water followed the conductivity of the system. It was concluded that the formation of blisters was mainly due to electroendosmosis ; osmosis accounted for about 6%, while 4% more can be attributed to hydration of ions. There are thirteen literature references. D. K.

1095. Deuterium exchange in trichlorethylene. L. C. Leitch and H. J. Bernstein. *Canad. J. Res.*, 1950, **28**, 35–6.—Trichlorethylene-*d*, $CDCl{=}CCl_2$, which was required for the synthesis of *sym*-tetrachloethane-d_2, CD_2ClCCl_3 was obtained in a nearly pure state by heating *sym*-tetrachlor ethane-d_2 with calcium deuteroxide and deuterium oxide. Previously all attempts at preparation of trichloethylene-*d* had ended in a mixture of the light and heavy forms. Exchange had evidently taken place in these reactions, one of which was the action of calcium hydroxide and water on tetrachlor-

ethane-d_3, and another reacting tetrachlorethane calcium deuteroxide and deuterium oxide under identical conditions. The infra-red adsorption spectra of all products are shown. This is the first report of deuterium exchange in trichlorethylene. A. D.

1096. Diazohydrocarbons. A. F. Mackay, W. L. Ott, G. W. Taylor, N. N. Buchanan, and J. F. Crooker. *Canad. J. Res.*, 1950, **28B**, 683.—Diazohydrocarbons have been prepared by the action of aqueous potassium hydroxide on 1-substituted-1-nitroso-3-nitroguanidines. Compounds obtained have been diazomethane, diazo-ethane, diazo-*n*-propane, diazo-*n*-butane, diazo-*n*-pentane, and phenyldiazomethane. The compounds were characterized as the 3 : 5-dinitrobenzoates. Potassium nitrocyanamide has been isolated as a by-product of this reaction. A. D.

1097. The evaporation rates of lacquer solvents. E. V. Elven, H. W. Rudd, and L. A. Tysall. *J. Oil & Col Chem. Assoc.*, Dec. 1950, **33** (366), 520.—Published methods of determining evaporation rates of solvents are reviewed and criticized. A method is described by which the rate of loss of solvent from a solution of a non-volatile plasticizer or nitrocellulose is determined by direct weighing. Results are expressed graphically and as a numerical series referred to an arbitrary standard. The apparatus can be considered in two parts: (*a*) the evaporation chamber and (*b*) the air-conditioning plant. Several diagrams are included. Methods of expressing results are: (1) graphical methods, percentage loss *vs* time, percentage of solvent in film *vs* time, mean rate of loss *vs* percentage loss, log percentage loss *vs* log time; (2) mathematical methods, best-fit polynomial, transformation, and (3) comparison with a standard solvent.

The effect of variations in rate of air flow, relative humidity, and sample weight is discussed, for two solvents, acetone and *n*-butyl acetate. It was shown that increase in airflow increased the rate of loss, increased sample weight, increased rate of loss on *n*-butyl acetate, and decreased the rate of loss on acetone. No evidence was obtained that the precision of the method was markedly affected by changes in relative humidity, sample weight, and rate of air flow. The different effects observed with butyl acetate and acetone seemed to involve a number of factors. Effect of variations in the " spreader " is also discussed. Other aspects considered are fundamental limitations of the method, comparison with other methods, and future possibilities. There are forty-five literature references. D. K.

1098. New oil-resistant rubber. Anon. *India-Rubber J.*, 1951, **120** (4), 149.—A new synthetic rubber, Lactoprene BN, announced by the U.S. Dept. of Agriculture, is said to be superior in some ways to natural rubber or other synthetic types. It may prove useful for gaskets, oil-seals, and linings for fuel tanks, but is unsuitable for automobile tyres because it lacks tensile strength and abrasion resistance. An important characteristic is the retention of properties over a wide range of temperatures from −40° to 300° F. C. N. T.

1099. Photosensitized reaction of carbon tetrafluoride. J. R. Dacey and J. W. Hodgkins. *Canad. J. Res.*, 1950, **28**, 173.—Calculations show that the strength of first C-F bond in CF_4 is probably >130th cal per mol. But it seemed possible that the bond could be broken with Hg (6^3P_1), since one of the products would be HgF, which has heat of formation of 32 k.cal. But no reaction occurred at measurable rate even at 300, hence may be concluded that energy to break this first bond must be greater than 112 k.cal Hg (6^1P_1) atoms. Also failed to produce any decomposition of CF_4. Hence concluded energy required is greater than 154 k.cal per mol.

Xenon atoms Xe($3P_1$) cause carbon tetrafluoride to decompose with a quantum efficiency of about unity to yield fluorine and an unidentified solid product. It is concluded energy required is more than 154 and less than 194 k.cal per mol. No other gaseous carbon fluorides, except CF_4, appear in the reaction products. All the fluorine disappearing from the gas phase would be accounted for if the solid product were the polymer $(C_2F_4)n$.

Hydrogen atoms produced from Hg (6^3P_1) at room temp and at 300% and from Hg (6^1P_1) at room temp do not react with carbon tetrafluoride. It is concluded from this that the activation energy of the reaction ($F_4 + H \rightarrow FC_3 + HF$) is not less than 14 k.cal per mol. A. D.

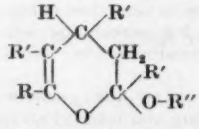
1100. Patents. H. de V. Finch and E. A. Peterson, assrs to Shell Development Co. U.S.P. 2,513,090, 27.6.50. A method of preparing unsaturated esters (1 : 1-diacyloxy-2-alkene) by passing a gaseous stream comprising acylic alpha, beta-olefinic aldehyde and a volatile, aliphatic, carboxylic acid anhydride, into contact with a solid phosphoric acid catalyst at a temp between about 150° and 350° C.

S. A. Ballard and B. P. Geyer, assrs to Shell Development Co. U.S.P. 2,513,132, 27.6.50. A method of preparing 3-aminopropanol by treating a mixture of acrolein and water with ammonia and hydrogen in the presence of a Raney nickel hydrogenation catalyst.

L. F. Hatch and T. W. Evans, assrs to Shell Development Co. U.S.P. 2,513,133, 27.6.50. Process for the preparation as a new chemical compound 4-hydroxy-3-hydroxymethyltetrahydropyran.

H. L. Johnson and F. J. Bondhus, assrs to Sun Oil Co. U.S.P. 2,513,179, 27.6.50. Alcohol is derived from 1-vinyl*cyclo*hexene-3, by treating with acetic acid, separating the acetic acid mono-ester and heating it with an aqueous alkaline solution, then separating the alcohol product.

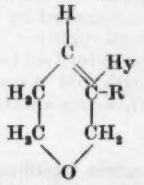
C. W. Smith, D. G. Norton, and S. A. Ballard, assrs to Shell Development Co. U.S.P. 2,514,168, 4.7.60. A new chemical compound, an ether having a structure represented by the formula.



R. R. Whetstone, S. A. Ballard, and C. J. Ott, assrs to Shell Development Co. U.S.P. 2,514,172, 4.7.50. Esters of dihydro- and tetrahydro-pyran carboxylic acids and polymers.

B. Barnett, assr to Shell Development Co. U.S.P. 2,513,615, 4.7.50. The preparation of pelargonyl beta-lactone which comprises reacting heptaldehyde with ketene in the liquid phase and with from 1 to 5 mol per cent of the total reactants of benzoylperoxide at a temp of about 85° C.

B. P. Geyer and R. H. Mortimer, assrs to Shell Development Co. U.S.P. 2,514,156, 4.7.50. Substituted pyrans, new chemical compounds having the structural formula



R representing a substituent radical from the group hydroxy methyl, formyl, and the carboxy radicals.

J. A. Patterson, assr to Standard Oil Development Co. U.S.P. 2,514,291, 4.7.50. A process for the production of secondary butyl alcohol from a mixture containing butanes and about 10 to 50 vol per cent normal butenes essentially free from *iso*-butylene. C. F. S.

CORROSION

1101. Conditioning water for secondary recovery of oil in the Appalachian fields. J. N. Breston. *Producer's Monthly*, May 1950, **14** (7), 16.—The principal objectives of water treatment are to prevent the clogging of sand pores, to minimize corrosion of equipment, and to treat the water to effect the removal of residual oil from the sand.

Standard treatment has been by the addition of inorganic chemicals, settling and filtering, and final treatment for stabilizing the water and reducing organic growth.

De-aeration and the use of " closed " systems greatly reduce corrosive tendencies of the water.

Recent advances in the use of organic compounds have resulted in treating the water with amine water-soluble chemicals which combine the necessary qualities of corrosion inhibitor and bactericide. The only additional treatment consists in filtration. Corrosion is reduced by the formation of a film on the metal, and after an initial concentration of 25 to 40 p.p.m., the quantity of injected compound may be cut down.

Results of two years of treatment by injection of RADA, Pur-o-San, and Arquad-S are discussed. Pur-o-San is particularly effective in reducing micro-biological growths.

Graphs and references. A. J. H.

1102. Corrosion and chemical testing of waters for sub-surface injection. J. W. Watkins. *Producer's Monthly*, Feb. 1950, **14** (4), 15; Mar. 1950, **14** (5), 30; Apr. 1950, **14** (6), 25.—The need for treatment of flood waters and brines is becoming more widely acknowledged. Two main requirements are that water should not corrode equipment and should not clog the sand face and pores. Precipitation may occur also within the sand at the interface of two waters of differing composition.

Treatment of the water is based on its chemical analysis, and field tests for this study were conducted from a mobile laboratory, which contained all essential equipment. Electrical power was supplied from a 1000-watt generator. Of seven possible variables in the observation of corrosivity of water, the type of test metal used, the duration of exposure, and velocity of flow and water pressure were kept constant; electrolytic corrosion was minimized; the variation in temp and quantity of dissolved gases and salts were observed. The loss in weight was then converted by the Speller formula to penetration in inches/year.

Routine analysis of the water is described in detail, for the estimation of dissolved oxygen, carbon dioxide, and hydrogen sulphide; pH; dissolved iron alkalinity and carbonate stability; hardness; chlorides and turbidity. The experimental procedure, preparation of solutions, and calculations are given.

References. A. J. H.

1103. Corrosion in water-flood operations. J. A. Prange. *World Oil*, Apr. 1950, **130** (5), 157–60.—Oxygen plays a great part in corrosion in secondary-water recovery. Open-pond aeration of water for repressurizing, etc., allow this agent to get in. Sulphides and CO_2 are also present. To combat corrosion three methods can be adopted: (1) changing the nature of corrosive agent, *e.g.*, by addition of inhibitors; (2) protective coatings—not completely satisfactory in these operations; (3) use of corrosion-resistant material, *e.g.*, cast iron is very unsatisfactory. Cathodic protection internally has not been satisfactory, and when used externally does not protect inside of pipe. Porcelain plungers are useful on pumps recycling brines, and asbestos-cement products are useful on salt-water disposal lines.

Photographs and micro-photographs illustrate the different types of corrosive attack. A. H.

1104. Design of anode systems for cathodic protection of underground and water submerged metallic structures. E. R. Shepard and H. J. Graeser, Jr. *Corrosion*, 1950, **6** (11), 360–75. J. T.

1105. Field and laboratory tests of sodium chromates and alkalis for controlling corrosion in gas condensate wells. C. K. Eilerts, R. V. Smith, F. G. Archer, L. M. Burman, F. Green, and H. C. Hamontre. *World Oil*, July 1949, **129** (3) 142; Aug. 1949, **129** (5) 173; Sept. 1949, **129** (6), 156; Oct. 1949, **129** (7), 174; Nov. 1949, **129** (8), 156; Dec. 1949, **129** (9), 160.—In 1944 the Bureau of Mines commenced investigations into the use of chromates in preventing corrosion of equipment of gas-condensate wells; this kind of treatment had been in use in other industries previously, but its behaviour under well conditions was unknown. Many wells of the Gulf Coast area are treated with chromates, but the suitability of a well to such treatment must be considered in each separate case.

The rate of corrosion of well-head test coupons was reduced from 0·045 inches per year to 0·002 inches, and iron content of the effluent from 100 to 3 p.p.m. by the injection of 1·23 lb of sodium chromate and 1·96 lb of sodium hydroxide per million cu. ft. The initial difficulty in the use of chromates was their reduction to insoluble

chromic oxide, but such reduction may be minimized by the maintenance of a high pH and the avoidance of a high chromate concentration.

Representative test results were obtained by varying to the utmost the operational conditions of the well and of the fluid flow. In the absence of injected water, the gas was under-saturated to the extent of 5 gal/million cu. ft.; in many tests 20 gal/million cu. ft. were injected, by diaphragm-actuated pumps, against a well-head pressure of about 2150 p.s.i. Wells in the Cotton Valley field were producing from the Bodcaw formation at an approx depth of 8460 to 8490 ft; the temp and average pressure of the formation were 238° F and 2850 p.s.i.

Carbon dioxide content is important in determining the rate and nature of corrosion, and depends on the concentration of salts, and on the presence of hydrocarbons. Isothermals give the solubility of pure carbon dioxide in distilled water under varying conditions of temp and pressure. Similarly, the pH of solutions of chromates and dichromates vary with the presence of other compounds, such as carbonates; the tendency with the latter is towards neutrality.

The theory of chromate and dichromate reactions is given. It is of great importance not to allow precipitation owing to the resultant restricted flow; hence the necessity for knowing the correct quantity of inhibitor to be used.

The tests on the use of chromates have extended over a period of twenty months, and may, therefore, be considered representative. Various concentrations were used and their inhibitory characteristics observed. Results are given in tabular and graphical forms. Iron content was determined in the field by the colorimetric method, and in the lab by the gravimetric method. Thus measure of the iron content gave an estimate of the extent of corrosion in the tubing, while corrosion-coupon tests at the well-head indicated the corrosiveness of the water after it had traversed the tubing. The injection of smaller quantities of chromate was accompanied, on occasions, by a reduction in iron content of the effluent, and an increase in well-head water corrosiveness, at which point the effectiveness of the chromate treatment had been utilized.

Varying quantities of sodium hydroxide were used in the treating solution to determine the extent to which chromate reduction was prevented. It was found that above 2 lb sodium hydroxide per million cu. ft. the effectiveness in increasing pH was inconsiderable. The use of dichromates, and the resultant water of low pH, showed that chromic acid solutions were more susceptible to reduction than chromate solutions of higher pH.

Tubing was withdrawn from a well and examined for corrosion and chemical deposition. The possibility of deposition of reduced chromic compounds on the sand face was also considered. Several tests were conducted to determine the solubility of the hydrous chromic oxide in various acids. Chromates are more easily reduced in some fields than others.

The results of tests are summarized, and it is concluded that much fundamental research is needed to verify the behaviour of the chromates under varying conditions.

Extensive data are given in tables and graphs. References. A. J. H.

1106. Inhibitor in stick form stops corrosion in Louisiana gas wells. G. M. Harper, Jr., *Petrol. Engr*, Nov. 1950, **22** (12), B-54.—Visual inspection of surface equipment indicated that severe corrosion was occurring. All damaged parts were replaced, including parts of the Christmas tree. A tubing caliper survey indicated that tubing corrosion, while present, was not serious. The insertion of test and analysis of the iron content of effluent further indicated that severe corrosion conditions obtained. Treatment was begun by dropping sticks of chemical inhibitor down the tubing. Using Kontol 115 results were not satisfactory, and tests were then carried out using Kontol 201. Better results were immediately apparent, iron content of condensate water being 7 p.p.m., compared with 200 p.p.m. before treatment and 120 after treatment with Kontol 115.

Using ½ stick Kontol 201 per 1 million cu. ft. gas produced, the iron content rose to 20 p.p.m., a permissible value. After fourteen months of this treatment a further caliper survey has shown no additional corrosion.

The cost of this treatment is approx $0·25/1 million cu. ft. gas produced. It is suggested that all gas-distillate wells should be checked for corrosion by analyses of water for iron. If corrosive conditions are apparent a more detailed survey should be made.

A colorimetric estimation of iron in water samples is described for field analyses.

C. G. W.

1107. A method of selecting protective coatings for offshore drilling structures. J. P. Barrett. *Corrosion*, 1950, **6** (11), 376.—A laboratory testing programme is described in which quantitative measurements are made of the protective coating characteristics. The tests carried out include moisture-vapour transmission, salt spray, and adhesion tests. Correlation between the laboratory and marine test station exposure was found to be 91%. J. T.

1108. Mitigation of oil field corrosion. P. L. Menaul. *World Oil*, Jan. 1950, **130** (1), 152–7.—Photographs show the severe corrosion which occurs in drill pipes, casing, pumps, etc. Formaldehyde treatment is effective in wells characterized by large water production and H_2S content of the brine. A. H.

1109. A new method for the protection of metals against pitting, tuberculation, and general corrosion. H. L. Kahler and C. George. *Corrosion*, 1950, **6** (10), 331.—A new principle for control of tuberculation and pitting of metals in water-side corrosion is discussed. It is termed the dianodic method and employs two anodic inhibitors, phosphate and chromate, under selective concentration and pH ranges. Its use in relatively low concentrations gives results superior to those obtained with single treatments of chromate, phosphate, etc., at much higher concentrations. It appears that the dianodic treatment does not act as two separate treatments of phosphate and chromate, but as a new single agency for the elimination of pitting and tuberculation. Pit reductions of 80–90% and more have been obtained with the dianodic method. J. T.

1110. Plastics combat well head corrosion in Galveston Bay fields. J. E. Kastrop. *World Oil*, Apr. 1950, **130** (5), 162–6.—Wells in the shallow waters of Galvaston Bay, subjected to salt spray and hot sun, have presented severe corrosion problems. Paint coatings lasted only a few months. The use of liquid plastic appears to be solving this problem. The plastic is a vinyl resin type, and six coats are applied after thorough sand blasting. Photographs illustrate the various operations. A. H.

1111. Reports on round table discussion on general corrosion problems. F. L. La Que. *Corrosion*, 1950, **6** (10), 327.—Nineteen questions on general and pipeline corrosion problems have been answered. J. T.

1112. Scale deposit prevention in gas lift wells. R. B. Walter. *World Oil*, June 1950, **130** (7), 228–31.—Many wells producing by gas lift and cutting high percentages of water experience scale-deposition troubles. It has been found that if a fluid could dissolve sufficient zinc for it to be present in the ionized state the scale formation is not only prevented but is removed if already formed. A zinc treater has been designed for installation at the bottom of the well, and is finding successful application. The treater consists of a series of alternate copper and zinc discs separated by brass spacer rings and strung on a steel rod. It is attached to a tubing when up for cleaning or lowered into well on a line. A. H.

1113. Selection of protective coatings for chemical fume resistance. C. C. Harvey. *Corrosion*, 1950, **6** (10), 323.—Accelerated laboratory tests with concentrated fumes, field tests, and tests on operating equipment all contribute to the development of an appropriate coating system. The need is emphasized for coatings to resist sulphur di- and tri-oxide, hydrogen sulphide, nitric oxides, chlorine, and hydrogen chloride gas or vapour in chemical plants, refineries, and paper plants. J. T.

1114. A study of some metals for use as permanent anodes in water-tank cathodic protection systems. A. L. Kimmel. *Corrosion*, 1950, **6** (11), 353.—Corrosion data are presented on a number of commercial metals and alloys used as permanent anodes. Investigations were carried out in water of pH 6·3 and 8·6; the latter having a higher alkaline-earth content. The metals studied include aluminium, stainless steel, iron, nickel, Inconel, and Monel. J. T.

1115. Surface potential method of corrosion survey of pipelines. O. W. Wade. *Corrosion*, 1950, **6** (10), 341.—The techniques of surface potential methods for corrosion

surveys on pipelines are reviewed, and the economics of conducting complete corrosion surveys on bare pipelines discussed. The economic aspects for determining location of galvanic-anode installations versus regularly spaced installations are also presented.
J. T.

1116. Use and abuse of insulated joints. M. E. Marshall. *Oil Gas J.*, 1.2.51, **49** (39), 70.—Basic purposes of insulated joints used in combating underground corrosion, and details of installations in construction of pipelines are described.

Insulated joints are installed to separate two sections of piping, or isolate one structure from others or to segregate a complete structure into units.

Hazards include flow of current across a joint between cathodic protected and unprotected structures, and in cases of a short circuit this can exceed 50 amp. Such an arc is capable of igniting inflammable vapours.

The very real danger occasioned by lightning can be negatived by installation of simple lightning arrestors at each insulated joint. G. A. G.

1117. The use of cathodic protection in conjunction with paint coatings. W. L. Crosby. *Corrosion*, 1950, **6** (11), 383. J. T.

1118. Patent. M. S. Baer, assr to Standard Oil Development Co. U.S.P. 2,513,131, 27.6.50. A method of inhibiting the corrosive effect of H_2SO_4 on ferrous metals by adding 2 to 30% by weight of boron trifluoride. C. F. S.

Engines and Automotive Equipment

1119. Diesel engines. Anon. *Auto Engr*, Feb. 1951, **41** (2), 61.—Notes written for the benefit of manufacturers exporting to Asian countries. Due to transport difficulties in that part of the world, there are often delays of one month in obtaining replacement parts. Axial self-starters and fuel-injection pumps present definite difficulties, and these restrict sales of diesel units. A solution is probably suitable modification of engine design to prevent neglect and abuse of engine. For example, fitting of small 2-stroke petrol-engine starters would eliminate abuse of electrical starter system. Alternatively, hydraulic starters might provide the answer. As regards fuel-injection pumps some revolution in design appears necessary to liberate them from costly service stations. The fine limits involved in fuel-injection pumps make it essential for highly skilled personnel to be available for service work, and in the East there is a shortage of such staff. Under such circumstances it is inevitable that fuel-injection pumps should produce troubles. Other difficulties encountered, with particular reference to the selection and performance of lubricating oils and crankshafts, are described. A number of recommendations are made which should help to reduce delays and avoid idle units while spare parts are being imported. A. S.

1120. Important British diesel-electric locomotives. Anon. *Gas Oil Pwr*, 1950, **45**, 328–35.—Describes the English Electric 800-b.h.p. diesel-electric locomotive, of which eight are to be supplied to Australia, and British Railways diesel-electric locomotive No. 10800.

The power unit in the Australian locomotives is an eight-cyl English Electric type 8SRKT four-stroke pressure-charged engine having cyl of bore and stroke 10 and 12 inches respectively It has a continuous rating of 800 b.h.p. at 750 r.p.m. Detailed constructional information is given. The Al-alloy pistons have three pressure and one oil-control ring above the gudgeon pin, and a scraper ring in the skirt. The inlet and exhaust valves, vertically disposed, are of Ni steel and Si–Chrome steel respectively. Dry-sump lubrication is employed. The scavenge pump draws oil from the sump and passes it through a radiator to the pressure pump, which supplies the main bearings. A low-pressure lubrication system, obtained from the high-pressure side through a reducing valve, is employed for the valve gear. Cooling water is circulated by a centrifugal pump.

A D.C. main generator rated at 600 V, 750 amps supplies current to four traction motors, which are force-ventilated. A 4·7-kW auxiliary generator supplies current for

the control circuits, lighting, etc. In working order the locomotive weighs 87 tons and has a max starting effort of 57,000 lb. Its max speed is 21 m.p.h.

The British Railways locomotive is powered by a Paxman Vee-form pressure-charged engine. It has sixteen cyl of bore and stroke 7 and 7¾ inches respectively, and develops 827 b.h.p. at 1250 r.p.m. giving a b.m.e.p. of 110 p.s.i. Details of the control equipment are given.

The B.T.H. main generator is a six-pole separately excited self-ventilated machine, and supplies current to four traction motors. An auxiliary generator and differential exciter are also fitted. In working order the locomotive weighs 69¾ tons and has a max starting effort of 34,500 lb. At 12·3 m.p.h. the continuous tractive effort is 18,500 lb, and its max speed is 70 m.p.h. H. C. E.

1121. Operating results in the Schöntal diesel power station. Anon. *Gas Oil Pwr*, 1950, **45**, 343.—This station at Winterthur, Switzerland, is equipped with four Sulzer two-stroke diesel engines each supplying 1050 b.p.h. at 500 r.p.m., coupled to three-phase generators. During the first two months of service the specific fuel consumption was 0·26 kg/kW hr and the specific lub-oil consumption (for cyl lubrication) was 1·57 g/kW hr. For crankcase oil the corresponding figure was less than 1·5 g.

All four engines can be put into operation by one man in less than ¼ hr. H. C. E.

1122. Engine-driven centrifugal pump calculations. T. G. Hicks. *World Oil*, May 1950, **130** (6), 169–72.—A method (with examples) of calculating performance data of internal-combustion engines when driving centrifugal pumps is given. Graphs show typical power–speed curve for a gas engine and performance curves for a centrifugal pump, while intersecting charts show daily operating costs (including approx lubricating costs) for various-sized internal-combustion engines using natural gas, oil, or gasoline fuels. A. H.

1123. Combination gas turbine–steam turbine unit. J. W. Blake. *Mech. Engng*, Jan. 1951, **73** (1), 14.—A complete year of operation has been attained with a 3500-kW simple-cycle gas turbine in combination with a medium-pressure steam-turbine. The initial six months' run was described in *Mech. World*, 29.12.50, **128** (3337), 607. The unit described is that at the Belle Isle (formerly Huey) station of Oklaholma Gas and Electric Company. An examination of the running hours shows that in the first year's run the availability was only 79·5%, but this was because of inspections made as a precautionary measure. Considering the time taken up by true maintenance only, the availability figure is calculated at 97·5%. The paper gives performance figures and carries out cost calculations, and concludes that for the application of a thoroughly new form of prime mover the first year's performance has been remarkable. The station economy improvement is of the order of 2½% reduction in heat rate, and a thermal efficiency improvement of ¼%. A. S.

1124. The Lancia "Aurelia." Anon. *Auto Engr*, Feb. 1951, **41** (2), 43.—In this latest Lancia car the engine consists of six cyl in Vee form arranged in two banks of three at 60°. The six-throw crankshaft has four bearings with adjacent crank-pins at 60°. The result of this arrangement is that the power unit is approx 6½ inches shorter than it would otherwise have been, and further space is saved by the removal of the clutch to the rear of the vehicle. Here it is incorporated with a combined gear-box and differential assembly driving the independently sprung rear wheels through universal shafts. The outer universal joints are situated outside the rear-wheel hubs in order to provide adequate length for the shafts. The integral body and chassis construction is adopted, and a notable point of design is the absence of centre door pillars. Six passengers can be carried, and the complete car weighs 22¼ cwt. The engine is of 70 mm bore, 76 mm stroke, and 1754 cc capacity. C.R. is 6·85 : 1, and at 4000 r.p.m. the max b.h.p. of 55·2 is obtained. Road speeds of over 90 m.p.h. are possible.

Further descriptions are given of the clutch, gear-box, final drive, rear suspension, front suspension, and steering and brakes. General-arrangement drawings of the various parts are included, together with comprehensive descriptions of these parts.

A. S.

1125. The largest British Doxford engine. Anon. *Motor Ship*, Jan. 1951, **31** (370), 288.—The largest unit of its class to be constructed in this country is the 8000 to 8500-b.h.p. six-cyl unit with lever-driven scavenge pumps, manufactured by Barclay, Curle & Co. Ltd., for 18,500-ton tanker *Polarbris*. The engine is described and illustrated by two photographs, and results of trials carried out in December 1950 are reported. The six cyl are 750 mm in dia, stroke of upper piston is 1050 mm and that of lower is 1450 mm, giving a combined stroke of 2500 mm. The engine has a rated output of 8000 b.h.p. at 104 r.p.m., and corresponding designed mean indicated pressure is 85 p.s.i. b.m.e.p. During the trials average figures for the official 4-hr test were : b.h.p. 8028; i.h.p. 9113; mechanical efficiency 88%; r.p.m. 104·4; m.i.p. 85·6 p.s.i. Pool diesel oil with a sp. gr. of 0·878 was used during the tests. U. M.

1126. Successful trials of a ducted fan. Anon. *Aeroplane*, 9.2.51, **80** (2064), 170.—The ducted-fan type of gas turbine incorporates an axial-flow compressor designed to deal with a large mass flow of air and running inside a duct. A general description is given of Aspin 1, a ducted-fan engine produced by Turboméca, which has completed 1000 hr running under the official control of the French Air Ministry. Reference is made throughout to a paper published in France by M. Faury. This unit has a dual-flow air system ; the air after passing through the axial compressor is divided into two streams, primary and secondary. First is that which receives energy of the fuel in traversing a gas turbine. Second consists of a centrifugal compressor, an annular-type combustion chamber, and a two-stage turbine which drives both centrifugal compressor and ducted fan. By the action of adjustable entry vanes the power absorbed by the compressor, and thus the thrust of the jet unit, can be varied through a notable range at constant speed. Another feature of the engine is arrangement for achieving optimum benefits from combined use of the adjustable shutters for controlling flow of air and delivery of fuel to the combustion chamber. In the case of achieving optimum cruising consumption, a given throttle setting determines speed of rotation which is maintained constant by a centrifugal governer, and position of vanes is adjusted to obtain best specific consumption. For rapid manœuvring, a button is pressed which, through a hydro-electric servo-motor, translates the controlling cams. In this way the speed of rotation is maintained at a max, the position of the throttle acts solely on the vanes which alone are used to achieve rapid variations of thrust. Weight of the Aspin 1 with all accessories is 264 lb, max dia is 23·6 in, and specific consumption 0·628 lb/lb/hr. U. M.

1127. The reheat factor in turbines and turbocompressors. J. Kestin. *Aircr. Engng*, Dec. 1950, **22** (262), 361.—The reheat factor of a turbine is defined as the ratio of the sum of the isentropic enthalpy drops across all stages, to the isentropic enthalpy drop across the whole turbine. The factors influencing the value of the reheat factor in gas turbines and turbo-compressors are examined, and an analysis is presented of the reheat factor for a gaseous working fluid under appropriate assumptions. The first two parts of the paper deal with the known methods of calculating reheat factors for both turbines and turbo-compressors with an infinite number of stages of equal efficiency. In Part III formulæ are derived for a turbine and a turbo-compressor with a finite number of stages, in which the working fluid is treated as a perfect gas with constant specific heats, equal isentropic stage efficiencies, and equal pressure ratios across each stage.

Results of calculations are presented graphically, and it is shown that, for turbines, values of the heat recovery factors depend almost linearly on the stage efficiency, whereas for compressors the heat loss factor depends linearly on the reciprocal of the stage efficiency.

Ten literature references are included. U. M.

1128. Supercharging of internal combustion engines. H. R. Ricardo. *Engineer*, 1950, **190**, 501–2; 519–22.—Reaction to supercharging of C.I. and spark engines differs because : (*a*) C.I. engine has no fuel present in cyl during compression stroke, and is therefore immune from detonation, (*b*) higher C.R. of C.I. engine renders it more sensitive to air-intake temp, since increase in latter results in greater increase of whole cycle temp, with consequent mechanical difficulties and loss of thermal efficiency. To augment emergency power output for supercharged military aircraft piston engines, detonation can be suppressed by using over-rich mixture, *i.e.*, at expense of high fuel

consumption. Further increase in power is obtained by injection of H_2O to supercharger. Effect of H_2O is two-fold; it cools by evaporation, while steam formed serves as anti-detonant, thus replacing excess fuel for same purposes. Mixture of MeOH and H_2O is better than H_2O alone. Above rated altitude, supercharger is at full capacity, but engine is O_2-starved. In early days of 1939–45 war, liq O was used, but was not entirely satisfactory; liq N_2O was successfully used instead, and this also proved an effective anti-detonant. For a fighter at 30,000 to 40,000 ft, N_2O gave 40 to 50 m.p.h. speed increase and doubled rate of climb. For supercharged racing-car engine, operating at speeds of 10,000 r.p.m. or more, it is advantageous to use a fuel giving a lower flame temp than that produced by hydrocarbons. Alcohol group give flame temp about 2300° C as against 2500° C for hydrocarbons. Alcohols are also good anti-detonants, and because of high lat. ht. of evaporation can absorb almost whole of heat of compression in supercharger. Racing fuel used in practice is blend of Et and Me alcohols, benzole, and acetone.

For passenger-car engines, so long as O.N. of available fuel is around 70, present C.R. of 7·0 : 1 is about optimum; engine is on edge of detonation at low speeds, and could not tolerate supercharging except in higher speed ranges. Average motorist requires high torque at low speeds, not addition to present top speed, and therefore there is no case for attempting to supercharge. C.I. engines respond favourably to supercharging. Higher density of intake air means shorter delay period and smoother combustion, also less sensitivity to Cetane No. and fuel volatility. Supercharging C.I. engines shows to best advantage at lowest end of speed range, eliminating diesel knock. C.I. engine cannot, however, use its fuel as refrigerant, as can petrol engine, and must depend wholly on heat exchange. Supercharger can be exhaust turbo-driven on C.I. engine. Bulk of high-speed diesel engines used for propulsion of heavy road vehicles, requiring high torque at low engine revolutions. Supercharged diesel ideal for this, and it should be possible to obtain same road performance from blown 5-litre engine as unblown 8-litre engine. Unfortunately, characteristics of existing blowers are not suitable for delivering small vol of air against high pressures when running slowly, and it seems some form of piston blower would be required. This is main objection to efficiency of existing supercharged diesels. Photograph and section of experimental diesel engine of about 40 b.h.p. per cyl shown, using piston supercharger between two working cyl and delivering alternately a double supercharge to each of them. This engine gives almost same power output as unblown four-cyl engine of same cyl dimensions.

A. C.

Safety Precautions

1129. Explosion hazards in repressuring oil wells. Anon. *World Oil*, Mar. 1950, **130**, 165.—Although undiluted natural gas may be compressed for injection into underground reservoirs, with little added danger, *Bur Mines Rep Invest.* 4557 ("Effect of high pressures on flammability of natural gas–air nitrogen") reports that the limits of flammability or exposability of natural gas–air mixtures cover a much wider range when pressure is applied. Control of O_2 content by introduction of inert gases provides an effective method of minimizing explosion hazards at atmospheric or lower pressures. A copy of *Rep Invest.* 4557 may be obtained free on application to Bureau of Mines Publication Distribution Section.

A. H.

1130. Fire protection problems in the petroleum industry. H. Brunswig. *Erdöl u. Kohle*, 1950, **5**, 606–11.—Examples of industrial pet fires are described (with illustrations). Pet fires are largely a human problem, in 1913–49 No. of garage and vehicle fires in Hamburg per year remained fairly steady despite large increase in motor transport. Modern fire-fighting equipment and precautions in storage installations are briefly outlined; the 45-m-dia crude storage tanks at the new Harburg refinery of Shell can have 120 m^3/min of foam applied. Water is of value in fighting oil fires and, contrary to previous views, is not the best extinguishing agent for water-miscible fluids such as ethyl alcohol. Such fires present a special problem, ordinary foams collapse rapidly with alcohol, but certain types of foam are obtainable which show relatively good alcohol-resistance.

V. B.

1131. Safe handling of H_2S bearing crudes. Anon. *World Oil.*, Mar. 1950, **130** (4), 181–4.—One of the problems arising from extensive oil development operations in the West Texas and Rocky Mountain provinces is the handling of crudes containing high concentrations of hydrogen sulphide gas. These can be handled with safety, providing operators and field personnel recognize the hazards and observe all precautionary rules. H_2S has a characteristic odour, but in high concentrations this odour may not be detected. It has a tendency to collect in low spots such as manifold pits, conduits, ravines, etc., where there is no adequate means for its dissipation. When a leak is discovered by a line-walker he should make no attempt to repair it, but should ask for assistance. Other leaks, *e.g.*, in pump-house, etc., and safety devices such as masks, etc., are discussed. A. H.

1132. Safeguarding plant from voltage reduction. II. Anon. *Mech. World*, 16.2.51, **129** (3344), 149.—Electrical equipment designed to operate on a steady voltage should be protected against lower voltages which might cause peculiar and sometimes dangerous conditions. The starting torque of an electric motor is approximately proportional to the square of the voltage, so a 10% reduction in the voltage might cause a 19% reduction in the normal starting torque. Curves show the speed-torque relationships for two types of squirrel-cage induction motor on normal voltage and on 90% of rated voltage. Both types show a greater torque than the resistance torque at all speeds up to full-load running speed when the voltage is reduced by 10%. In the case of the single-cage motor, however, the motor torque on 90% voltage exceeds the standstill resistance torque by only 3%, and any further reduction in voltage or slight increase in static friction would prevent the single-cage motor from being self-starting. Should a squirrel-cage motor fail to start, it will take a very high current and the winding will quickly burn out. Therefore no motor should remain energized from the supply when stalled. The paper describes methods of overcoming difficulties due to voltage fluctuations, and further information on this subject will be supplied at a later date. A. S.

1133. Safety training by specific practice problems. Part 1. Drilling rig safety—rotary tongs. J. I. Powell. *World Oil*, Apr. 1950, **130** (5), 114–20.—The first of a series on rig accidents. An original analysis was made of 700 accident experiences involved with the overall operation of a drilling rig. It was found that eighty-one were connected with the handling and use of rotary tongs.

With the aid of sketches the more serious accidents are described. These were usually due to carelessness or fatigue of operators. In some cases the men would have avoided serious injury if they had appreciated they were within a dangerous area.

The author hopes that by detailing these accidents not only will crewmen become more safety conscious, but also that equipment manufacturers by knowing the accidents which have occurred will be able to effect improvements where required in their designs. A. H.

1134. Safety training by specific practice problems. Part 2. Drilling rig safety pipe-handling through V-door, on catwalk, and across. J. I. Powell. *World Oil*, May 1950, **130** (6), 111–16, 121.—This phase of rig practice accounted for 11·4% of the total investigated. The most severe accidents occur while pipe was inbound or outbound through V-door. In some cases the chief sufferers were men not actually engaged in pipe handling. While individual accidents may appear to be due to foolishness, combined accident analysis shows that action is required to avoid similar recurrences, *e.g.*, the smashing of many toes on the catwalk could be avoided if loose cross-boards thicker than a man's lower instep were used to hold dropping pipe above a man's foot. A. H.

1135. Safety training by specific practice problems. Part 3. Drilling safety rig—pipe slips and elevators. J. I. Powell. *World Oil*, June 1950, **130** (7), 180–6.—10·8% of the accidents examined occurred in connexion with pipe slips and elevators. Allowing swinging elevators to come too low has caught mens' hands between elevator horns and the top of the extended tool-box. Starting the pick-up before elevators are properly latched has caused some accidents. Careful control by the driller is required. Worn slips cause a hazard to crewmen by reducing the clearance between handles and rotary table. Attaching slips to downward-moving pipe is also risky. Slip setters

should be taught where and where not to place their feet, and drillers should keep very careful control of downward-moving pipe, especially when the top single of the stand starts through the rotary. A. H.

1136. Safety training by specific practice problems. Part 4. Pipe stabbing, racking and spinning practices. J. I. Powell. *World Oil*, July 1950, **131** (1), 103–6.—Of the 700 accidents examined, thirty-five were associated with pipe stabbing, eleven with racking, and twenty-one with manipulating spinning and make-up lines. Many accidents were due to hands being placed in unsafe positions during racking and unracking. Others were due to drillers running elevators into the top box too fast, and thus causing the pipe stabber to lose his grasp. Drillers should operate rigs at a safe speed, and also develop safe habits among their tool-pushers. One fatal and two minor accidents were due to plugs of ice blown from the drill string. When weather is very cold these plugs are liable to form in the pin end of racked pipe and are not easily observed.
A. H.

Miscellaneous

1137. The black gold of the Pyrenees. A. W. J. Mayer. *Ingenieur*, 12.1.51, **63** (2), P A.11.—Describes the history of petroleum production in Southern France. This is followed by a description of recent developments, particularly with regard to the production of natural gas, and figures are quoted showing the increasing outturn of this material. Only passing reference is made to the many other products obtainable from petroleum. R. R.

1138. How to interpret earnings changes in an oil company. E. W. Korsmeyer. *Refiner*, 1950, **29** (11), 109–12. (*N.A.C.A. Bulletin, National Association of Cost Accountants*, July 1950.)—A method is presented of preparing earnings statements to show factors affecting changes in earnings. Causes of changes are traced, and more especially, changes in sales returns separated into changes in volumes sold and changes in prices of products sold. The advantage claimed for the procedure is that any one month may be readily compared with any other month. Illustrative tables are given. R. W. G.

1139. Industry can meet 1951 demands, barring restrictive regulations. E. T. Knight. *Oil Gas J.*, 25.1.51, **49** (38), 200.—Total demand for all oils in the U.S.A. in 1951 is forecast at approx 7,115,000 b.d., 5·3% above 1950, which can be met by domestic production if not burdened by restrictive regulations.

Tables show demand and supply of petroleum products, forecasts, and cars, trucks, and buses in the U.S.A. G. A. C.

1140. Metallic gaskets given boost by oil industry development. H. M. Dunkle *Refiner*, 1950, **29** (11), 135–9. (*A.S.M.E. Petroleum Mechanical Engng Conf., New Orleans*, Sept. 27, 1950.)—The use of gaskets in the making of joints is discussed. Several metallic gaskets are mentioned, including corrugated soft iron, jacketed asbestos and oval and octagonal soft-iron rings. The last type are used for high-pressure–high-temp service. The oval shape is cheaper, but for critical high-pressure service the octagonal type is to be preferred, giving a wider contact face when first installed and requiring a smaller bolt stress. Some general advice on gasket use is given, suggesting cleaning of flange faces, protection of gaskets, careful fitting, including uniform bolt stressing by small increments, and non-re-use of gaskets. R. W. G.

141. More British petroleum chemicals. I.C.I.'s Wilton works. Anon. *Petroleum*, Nov. 1949, **12** (11), 288–9.—A brief description of the new works, which has two major activities—the cracking of oil for the production of basic organic chemicals, and the electrolysis of brine for the production of chlorine and caustic soda. R. E. P.

1142. New construction to boost refining capacity 110,000 bbl daily. R. B. Tuttle. *Oil Gas J.*, 25.1.51, **49** (38), 244.—Capacity on new and expanded facilities for production of blending components and upgrading of various gasolines in the U.S.A. and Canada scheduled for completion in 1951 is approx 75,000 b.d.

Active refinery-building projects and refinery projects completed in 1950 are used. G. A. C.

1143. New field processing plants exceed billion-foot daily capacity. R. B. Tuttle. *Oil Gas J.*, 25.1.51, **49** (38), 251.—Natural-gas processing plant building and completed projects in the U.S.A. and Canada are listed.

Combined capacity is approx 975,000,000 cu. ft/day of natural gas.

Five major petrochemical plant projects are also under way. G. A. C.

1144. Pipeline communication equipment. Anon. *Petroleum*, Dec. 1949, **12** (12), 311–12.—Reviews some aspects of pipeline communication and the use of radio equipment. V.H.F. and micro-wave systems are explained. Ranges for V.H.F. equipment depend on frequency, but 15 to 30 miles can usually be obtained between vehicles and a fixed station, and " walkie-talkies " have a range of 3 to 6 miles. Controls are very simple, consisting of an on/off switch, a volume control, and a press-to-speak button on the microphone. Costs may be much less than the maintenance of a telephone system of equivalent length.

Descriptions of a " walkie-talkie," multi-channel airborne equipment, and a V.H.F. transmitter/receiver primarily intended for installation in moving vehicles are included. All these are designed to facilitate communication between moving groups. R. E. P.

1145. Pipe lines set record-breaking pace in 1950—build 20,000 miles. P. Reed. *Oil Gas J.*, 25.1.51, **49** (38), 219.—Tables show principal domestic and foreign crude oil, products and natural-gas pipelines planned, under way, and completed.

It is estimated that length of new pipeline construction in 1951 will be between 19,000 and 20,000 miles. G. A. C.

1146. Progress at Europe's largest refinery. Anon. *Gas Oil Pwr*, 1950, **45**, 336–7.—Describes the work in progress at the Anglo-American Oil Co.'s refinery at Fawley, which is due to begin production at the end of 1951, and when complete will handle 40 million brl oil per year. Fawley was chosen because of its excellent harbour facilities and its position as a distribution centre. H. C. E.

1147. Refining industry well prepared to conform to wartime program. G. Weber. *Oil Gas J.*, 25.1.51, **49** (38), 215.—A review of production trends of motor fuels, aviation gasoline, jet fuels, diesel fuels, lubricating oils, aromatics, catalytic reforming, and cracking leads to forecast that for a short-of-war programme, military demand can be superimposed on a record civilian consumption in the U.S.A. without serious shortages or sacrifice of quality. G. A. C.

1148. The suspending power of detergent solutions. II. Soap builder solutions. A. S. Weatherburn, G. R. F. Rose, and C. H. Bayley. *Canad. J. Res.*, 1950, **28F**, 363.—The ability of alkaline salts, used as a laundry soap builders, to hold carbon particles in suspensions has been measured. Little difference was noted between individual builders, if soap absent, all suspending powers were poorer than that of distilled water. Generally, increase in concentrations of builder in soap solution decreased suspending power. The three classes of builders are simple electrolytes, silicates, and phosphates. In each group suspending power of a built soap solution increases with decreasing pH of solution. The influence of added builders may be explained on the basis of interference with the normal adsortion of soap by carbon particles, and in some cases the superimposed adsorption of the anion of the builder. If builders are classified on this effect the sodium hexametaphosphate is best, while sodium hydroxide and sodium hyposilicate are the poorest. There are only minor differences between the remaining builders. The classification on suspending power is not necessarily indicative of the over-all efficiency of builders on the detergent process as a whole. A. D.

1149. Welding quality control in a petroleum refinery. A. F. Blumer. *Refiner*, 1950, **29** (11), 101–8. (*A.S.M.E. petroleum div'n conf., New Orleans*, Sept. 1950.)—A paper based on the practice at Baton Rouge refinery, which employs ninety-six welders (not including supervisory personnel), apart from contract welders. Work includes pipe welding, plate and structural welding, storage-vessel and alloy welding for the large number of units on the refinery. These items are discussed, together with welders' qualification tests, welding inspection, welding procedure, evaluation of welding electrodes, and welding research.

Principal points mentioned on quality control are: (1) selection of proper personnel by qualification tests; (2) inspection of welds (in progress, and finished) and instruction of welders; (3) development and use of suitable welding procedures; (4) testing and evaluation of welding electrodes, and (5) conduction of welding research on suitability of procedures. R. W. G.

1150. Patent. F. J. Buchmann, assr to Standard Oil Development Co. U.S.P. 2,512,608, 27.6.50. The formation of a synthesis catalyst by spraying molten iron containing activating material on to pieces of aluminium in a reducing atmosphere. C. F. S.

BOOK REVIEWS

The Chemical Formulary. Vol. IX. Editor-in-Chief H. Bennett. Brooklyn, N.Y.: Chemical Publishing Co. Inc.,* 1951. Pp. xvi + 648. $7.

Another volume of the well-known "Chemical Formulary" series is now available, and is the ninth volume in this most important work.

It is important not only from the point of view of its thousands of industrial formulæ which are brought up to date to cover the newest developments in any particular field, but also from its value as a reference book to manufacturing chemists, consultant chemists, and in fact to anybody however remotely connected with the chemical industry.

The publishers claim this to be a collection of valuable, timely, practical, commercial formulæ for making thousands of products in many fields of industry, and the reviewer of this latest volume wholeheartedly agrees. It is interesting to note here that no duplications of any formulæ appear in any of the volumes.

An alphabetical list of chemicals and trade-mark products with the names of their manufacturers is included. C. F. S.

Wells of Power. Olaf Caroe. London: Macmillan & Co. Ltd., 1951. Pp. xx + 240. 15*s*.

With oil production in the Middle East nearing 100 million tons a year the vital importance of this region to Western civilization becomes more and more evident, as does the need for some understanding of its major political and economic problems by the public here and in America.

Sir Olaf Caroe's short and extremely readable book is therefore timely, although for those who wish to go deeply into the problems of the Middle East it will supplement rather than replace more specialized studies. In a series of brilliantly written chapters Sir Olaf deals with the general physiognomy of the countries round the Persian Gulf, their place in world history, the background and flavour of the Islamic civilizations, and the economic effects of recent developments, and thence proceeds to an assessment of the political and strategic weaknesses of the area, enhanced as these latter are by the consequences of the British withdrawal from the Indian subcontinent. The remedy which he proposes—a new formal alliance on the lines of the Atlantic Pact—will no doubt be widely discussed.

Sir Olaf's tenure of the secretaryship of the External Affairs Department of the Government of India from 1939–46 gives special authority to his historical outline of the relations of the principal European powers with the countries of the Middle East; this includes a revealing picture of the persistence of Russian attempted penetration into the Persian Gulf area. The great importance, both economic and political, of

* Available in London from Chapman and Hall, Ltd.

the large-scale participation by American companies in the Middle East oil industry receives full recognition.

For industry readers, the value of the chapters dealing with oil consists not so much in their recapitulation of well-known facts as in the sympathetic and imaginative approach to the human problems arising out of the meeting, due to the oil developments in this region, of the representatives of contrasting cultures and of widely different levels of material civilization. While the author's insistence on the need for a wise use by Middle East countries of the new wealth created by oil will command general acceptance, some of his proposals to this end seem to pass over too lightly the depth and reality of existing political divisions in the area.

The author can scarcely be blamed for the fact that, since the book went to press some details of the information given have been outdated by events. This applies, for example, to the map on page 94 showing pipelines. On the other hand, fuller information regarding the terms of oil concessions in the Middle East might well have replaced a perhaps rather irrelevant note on Canadian oil. T. C. O.

ADDITIONS TO THE LIBRARY

Elements of Petroleum Subsurface Engineering. H. Vance. Saint Louis: Educational Publishers, Inc., 1950. Pp. vi + 168.

Safety in Petroleum Refining and Related Industries. Compiled by G. Armistead, Jnr. New York: John G. Simmonds and Co., Inc., 1950. Pp. 416.

Report of Symposium on Standardization in the Chemical Field. London: Royal Institute of Chemistry, 1950. Pp. 38. 3*s.* 6*d.*

Report of a Symposium on Microbalances. London: Royal Institute of Chemistry, 1950. Pp. 48. 5*s.*

British Standards (British Standards Institution, London).

B.S. 1507, 1508: 1950. **Steel Pipes and Tubes for Pressure Vessels.** Pp. 38. 10*s.* 6*d.*, post free.

B.S. 1134: 1950. **The Assessment of Surface Texture Centre-Line-Average-Height Method.** Pp. 51. 6*s.*, post free.

B.S. 1692: 1950. **Gin Blocks for Fibre Rope.** Pp. 14. 2*s.*, post free.

B.S. 959: 1950. **Internal Micrometers (including Stick Micrometers).** Pp. 15. 2*s.*, post free.

B.S. 1684: 1950. **Forged Steel Socket. Welding Fittings for the Petroleum Industry.** Pp. 8. 3*s.*, post free.

B.S. 1663: 1950. **Higher Tensile Steel Chain (Electrically Welded).** Pp. 19. 2*s.* 6*d.*, post free.

B.S. 1700: 1950. **Typical Ships' Derrick Rigs.** Pp. 33. 7*s.* 6*d.*, post free.

B.S. 1701: 1950. **Air Filters for Internal Combustion Engines and Compressors.** Pp. 31. 4*s.*, post free.

B.S. 148: 1951. **Insulating Oil For Transformers and Switchgear.** Pp. 65. 6*s.*, post free.

B.S. 235: 1951. **Gears for Traction.** Pp. 17. 2*s.*, post free.

B.S. 1704: 1951. **General Purpose Thermometers.** Pp. 10. 2*s.*, post free.

B.S. 1365: 1951. **Short-Range Short-Stem Thermometers.** Pp. 13. 2*s.*, post free.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER
April 1951

The following have applied for admission or transfer to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, Associate Fellow, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Applications for Membership

ALLEN, Derek Victor, technical assistant, Messrs. W. B. Dick & Co. Ltd. (*J. Romney ; W. R. Steet.*)

ANDREWS, Eugene, plant operator, Anglo-Iranian Oil Co. Ltd. (*A. E. Holley ; R. B. Southall.*)

CARLILE, John Hildred George, Principal Scientific Officer, Department of Scientific and Industrial Research. (*C. M. Cawley ; F. H. Garner.*)

DOGGETT, David Stanley, assistant engineer, Anglo-Iranian Oil Co. Ltd. (*M. A. L. Banks ; S. W. Adey.*)

EDDEN, Joseph John, fitter and turner, National Oil Refineries Ltd. (*H. Griffiths ; L. G. Grove.*)

FRASER, Alexander Munro, wharf superintendent, London and Thames Haven Oil Wharves Ltd. (*A. E. Duck ; J. Mitchell.*)

HALE, Alfred Ronald, research student, University of Birmingham. (*F. H. Garner ; F. Morton.*)

IRWIN, Davis Lambert, assistant works manager, The Ruberoid Co. Ltd. (*E. J. Sims ; W. E. J. Broom.*)

MOSCISKER, Julius, mechanical engineer, Eagle Oil & Shipping Co. Ltd. (*G. C. Carr ; W. R. Davies.*)

NAIR, Chundolli Narayanan, chemist-in-charge, Assam Oil Co. Ltd. (*G. R. Nixon ; S. T. Minchin.*)

SELINA, Anthony, instrument engineer, Messrs. E. B. Badger & Sons (G.B.) Ltd. (*C. Paysant ; R. Sharp.*)

ST. LEGER, John Anthony, student, School of Mines, Cornwall.

SWEENEY, James Napier, general manager, Luzon Stevedoring Co. Inc. (*A. W. Black ; W. R. Winget.*)

VAN WAGENINGEN, G., managing director, Netherlands Sun Oil Co. (*C. B. Smith ; F. F. Musgrave.*)

VIKTORSSON, John Harry, engineer, Messrs. A. Johnson & Co. Ltd. (*F. R. Banks ; C. L. Goodwin.*)

WALSH, Arthur James Patrick, assistant installation manager, Shell Petroleum Co. Ltd. (*E. J. Sturgess ; H. R. Holmes.*)

Transfers

BADDELEY, Alan Rowland Walsworth, research chemist, Monsanto Chemicals Ltd. (*F. H. Garner ; E. R. Palmer.*) (*Student to Associate Fellow.*)

RULE, Peter Lewis, operator, Anglo-Iranian Oil Co. Ltd. (*D. B. Watt ; C. E. J. Langdon.*) (*Student to Associate Fellow.*)

NEW MEMBERS

The following elections have been made by the Council in accordance with the By-laws.

Elections are subject to confirmation in accordance with the By-laws.

As Fellows

COVA, C. P. DE LA
DIMITRIU, C. A.
SNOW, P. H.

As Member

HOLMES, J. B.

As Associate Fellows

BURGESS, H. G.
BURJORJEE, H. R.
DANIEL, S. G.
FREEBORN, A. S.
HALL, R. T. W.
JENKINS, T. E.
MILES, P. F.
NICOLL, H. G.

Transferred from Associate Member to Associate Fellow

COBLEY, R. C.

Transferred from Students to Associate Fellows

JONES, M. T. B.
MORRIS, D. M.

As Associate Members

CROWLEY, J.
MACKIAN, J.
STEVENSON, S.

As Students

BROWN, D. D.
GREW, J. E.
REID, W. D.

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SAID THE ANODE

TO THE CATHODE

'Rusting's not what it was. Remember when, between us, we used to get through something like £900,000,000 worth of iron and steel every year?'

'And worth three times that now', said the Cathode.

'These corrosion committees', said the Anode, spitting a stream of metal ions. 'Importance of surface preparation and red lead priming. Anodic suppression . . . ! Putting ideas like that about. How are we expected to live?'

'We're not', said the Cathode. 'The latest horror is a paint that suppresses *me* as well. Modified red lead of some kind. Calcium Plumbate's the pigment. Not even sea water's going to help us when they start using that. Wish I could remember the name'.

'I give up', said the Anode. 'Science just makes life more difficult . . . What's that noise?'

'Sounds like a brush to me', said the Cathode, 'and by the speed it's coming up it must be using that new paint. Brushes out fast and covers like the devil'.

'Look out!' said the Anode.

'*This is it*', said the Cathode—**'RUSTODIAN'.**

***Rustodian** is made in self-colour peach, standard Light Stone and B.S.S. colours Light Brunswick Green, Dark Battleship Grey, and Imperial Brown.*

*An iron surface is never perfectly uniform and in the presence of moisture a number of electric cells form on its surface. Iron dissolves from the anodes causing progressive corrosion and pitting. At the same time, in certain circumstances, (such as in the presence of sodium salts from sea water), chemical compounds forming at the cathodes tend to destroy the paint film. Rustodian suppresses electrolytic action at both anodic and cathodic areas, and therefore retards the destructive effects arising from these causes.

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ASSOCIATED LEAD MANUFACTURERS LTD

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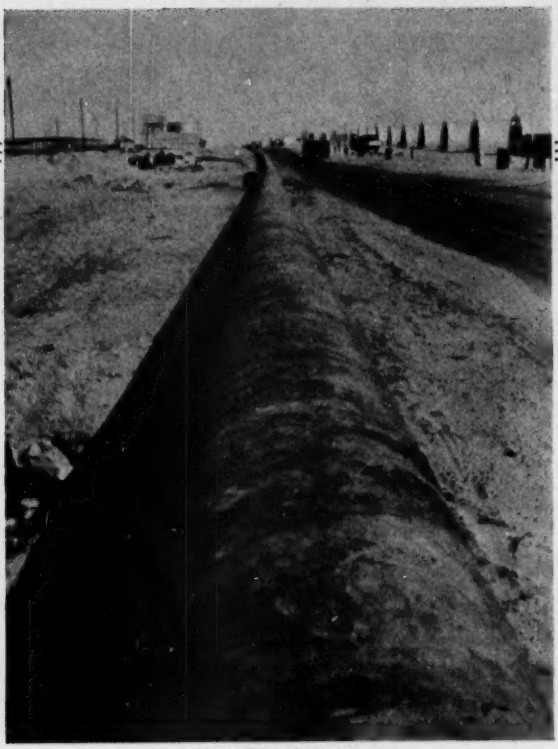

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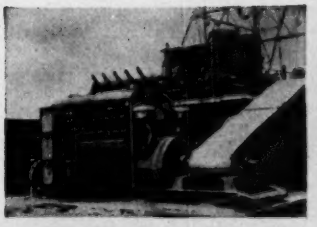

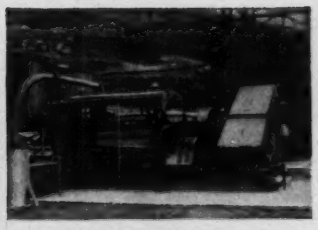

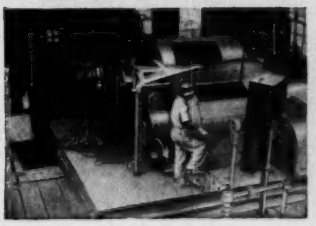

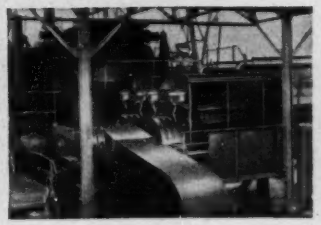

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Illustrated are Paxman powered drilling rigs in four of the many oil-fields in which they are used. Individual Paxman power units for oil-well drilling range in output from 90 to 665 b.h.p. Noteworthy features of these plants are high performance-durability and mobility backed up by an efficient comprehensive service and spares programme available throughout the world.

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equipped with a *BAKER* JUNK PUSHER

which pushes junk or debris down the hole ahead of the Retainer, and greatly minimizes the hazard of premature tripping of the Retainer by the fouling of the slips.

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Baker Model "K" Cement Retainers are available made of Magnesium Alloy, which are readily drilled up by using drill pipe, tubing or cable tools, since all large parts are made of magnesium, except the nitricast-iron slips which are easily broken up. Magnesium Retainers have ample strength to withstand any pressure which can be imposed safely upon the casing or liner. Although Baker MAGNESIUM ALLOY Cement Retainers are satisfactory for *temporary* bridge plugs, they may be affected by well fluids, and CAST IRON Retainers are recommended for *permanent* bridge plug installations.

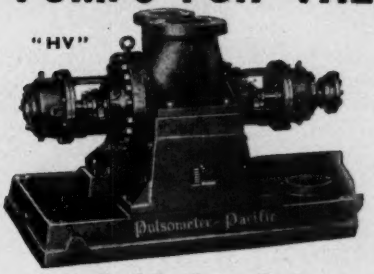
OPERATION OF THE BAKER JUNK PUSHER

The Baker Junk Pusher (Product No. 403) has an outside diameter slightly smaller than the inside diameter of the casing in which the retainer is run. All debris tends to collect in the Junk Pusher. Slots permit passage of displaced fluid, but prevent passage of junk or debris which might foul the slips and result in premature tripping of the Retainer. The internal Screen, held in place by friction, prevents debris from entering the body of the Retainer, and is blown out at the proper time by the Tripping Ball Seat.

Pulsometer-Pacific

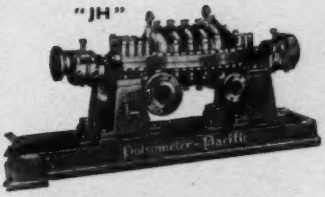
PUMPS FOR THE OIL INDUSTRY

"HV"



Vertically Split Casing Single-Stage Hot Oil Pumps.

"JH"



Horizontally Split Casing Multi-Stage Pumps for Hot Oil.

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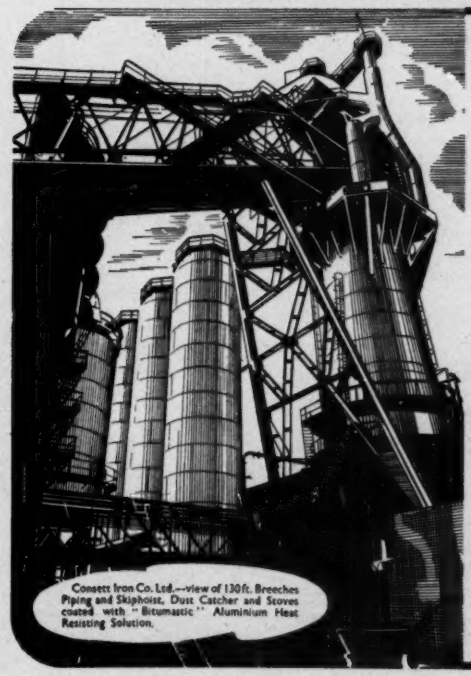
ENGLAND



Consett Iron Co. Ltd.—view of 130 ft. Breeches Piping and Skiphoist, Dust Catcher and Stoves coated with "Bitumastic" Aluminium Heat Resisting Solution.

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WAILES DOVE BITUMASTIC LTD.,
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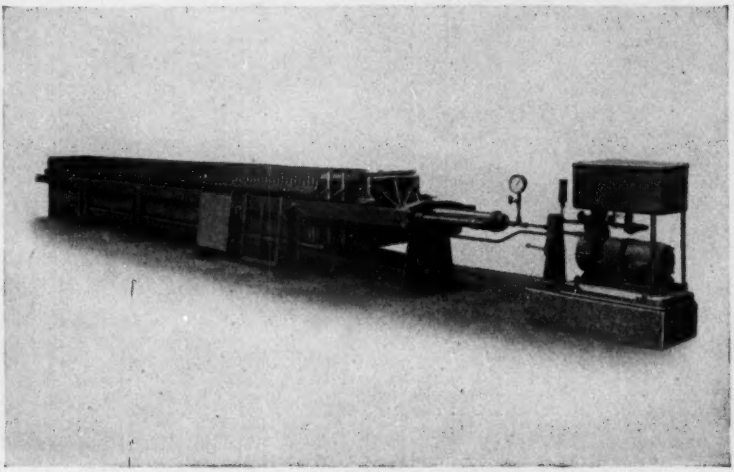

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OUR wide and long experience in the manufacture of wax moulding presses makes us specially suited to meet the most varied demands. May we submit proposals to suit your requirements?

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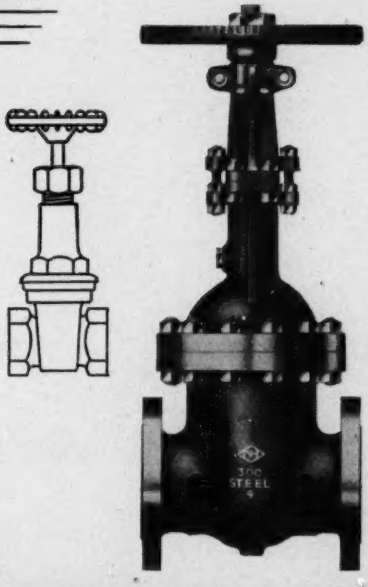

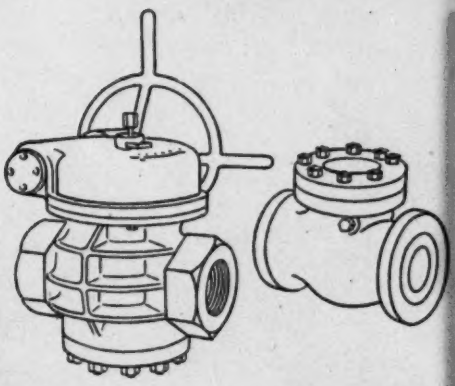

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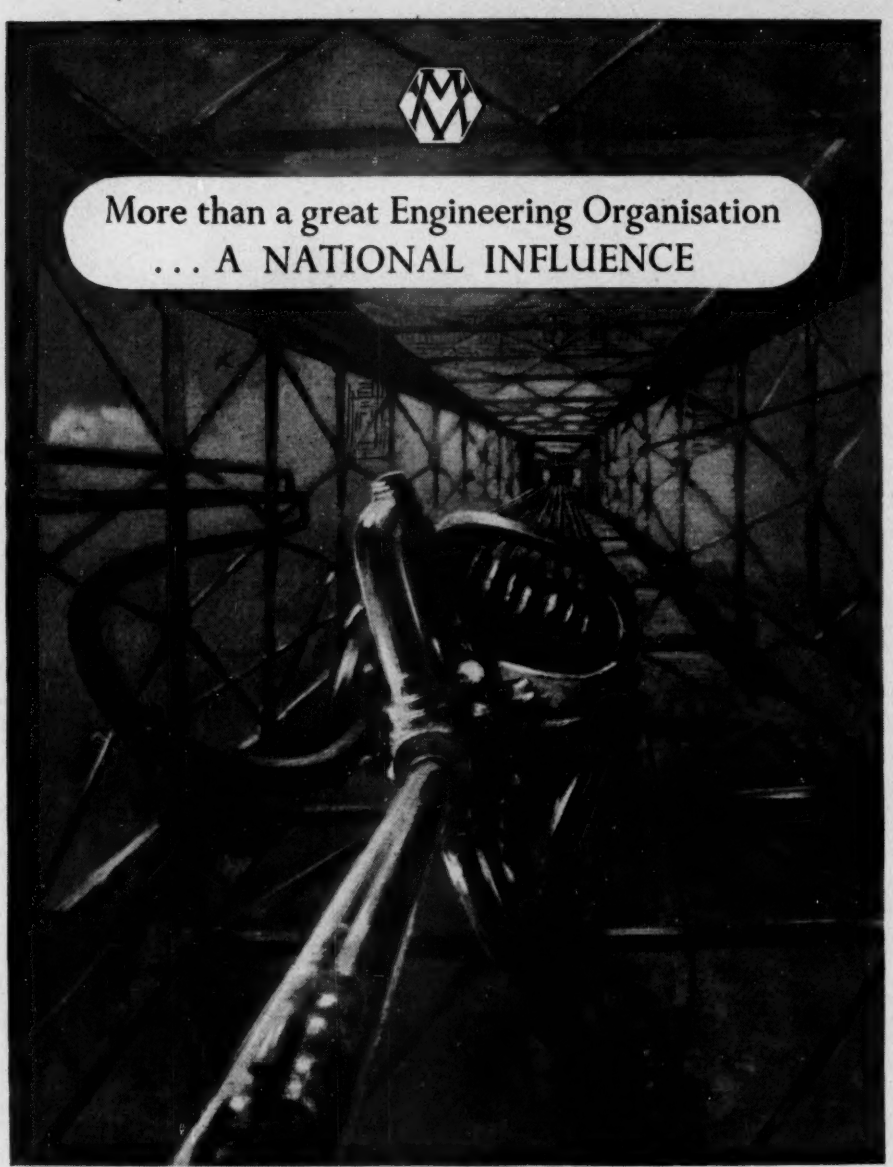

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SAUDI ARABIA—Saudi Electric Supply Company, Mecca, P.O. Box No. 94, also at Taif.
ARGENTINA—M.V.E. Export Co. Ltd., Avenida Pte. R. Saenz Pena 636, Buenos Aires.
IRAQ—Dwyer and Co. (Iraq) Ltd., Airlines House, King Faisal II St., Salhiyah, Baghdad West.
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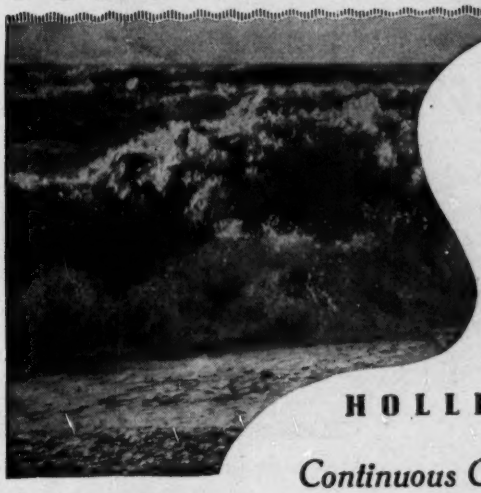

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FOUR LLOYDS AVENUE, LONDON, E.C.3.

Esso
These crude distillation units are but two of the many units which, when completed, will comprise the largest refinery in Europe. They are being constructed by Foster Wheeler Ltd., for the Anglo-American Oil Co. Ltd., at Fawley, Southampton. 'Fleetweld 5' and Lincoln Welders are being used exclusively on this major project.

An Esso photograph by William Martin Ltd.

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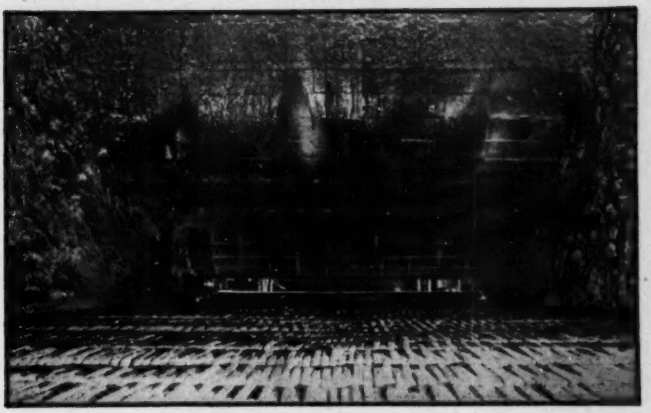

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Made from selected fireclays by most modern methods under constant laboratory control "Nettle" and "Thistle" have set a standard for consistency of quality.

Full particulars of our Firebrick Brands, Refractory Cements, Castables and Concretes will be gladly sent on request.

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from "The Pipe Book" by Alfred Dunhill

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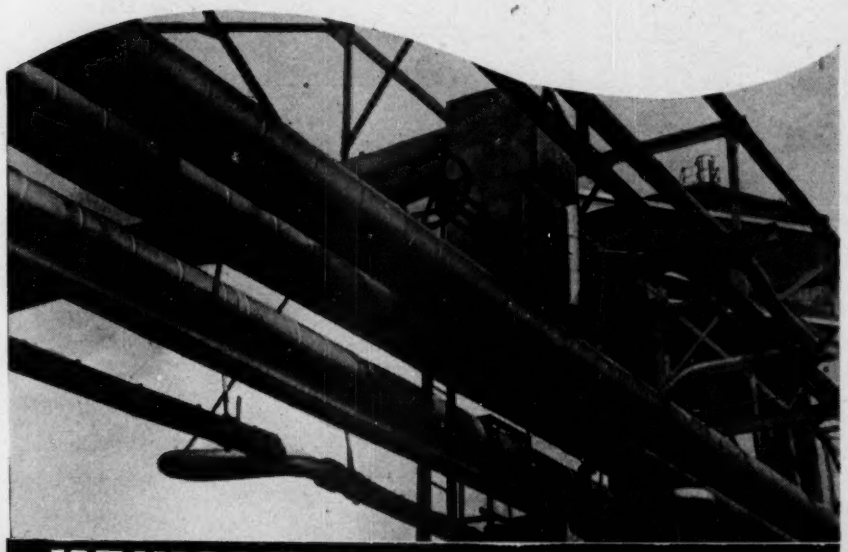
French pipe makers excel in pipes of graceful design and execution, subjects of topical interest often being chosen. The illustration shows a fine example, a portrait of a Crimean veteran.

INDUSTRIAL PIPING

The industrial pipe does not lend itself to such ornate design; efficiency is more important. KENYON will survey your plant and put forward schemes of heat insulation representing the best balance between capital expenditure and the year-by-year saving which proper insulation ensures. Installations carried out in any part of the world.



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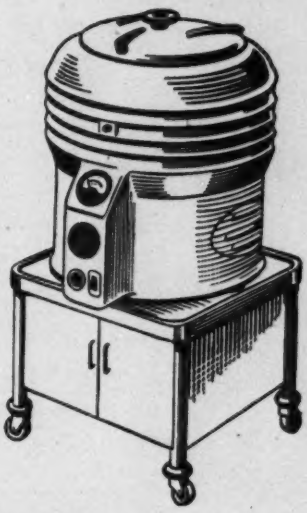

This new machine has been specially designed for carrying out all the standard centrifuging oil and petroleum tests of the I.P., A.S.T.M. and A.P.I., using one basic head, merely by changing the various accessories to suit the glassware peculiar to different tests.

Full details from the manufacturers:-

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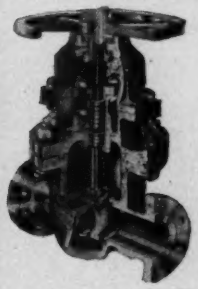

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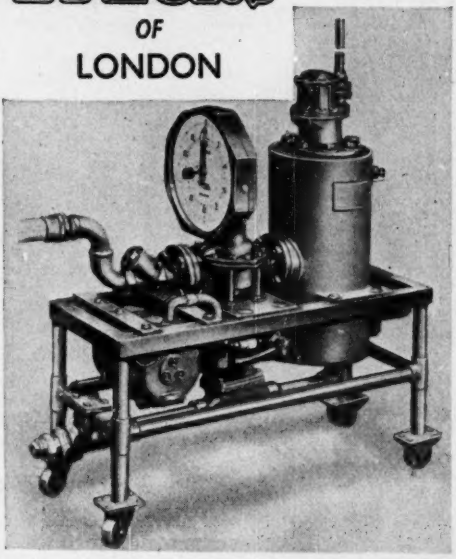

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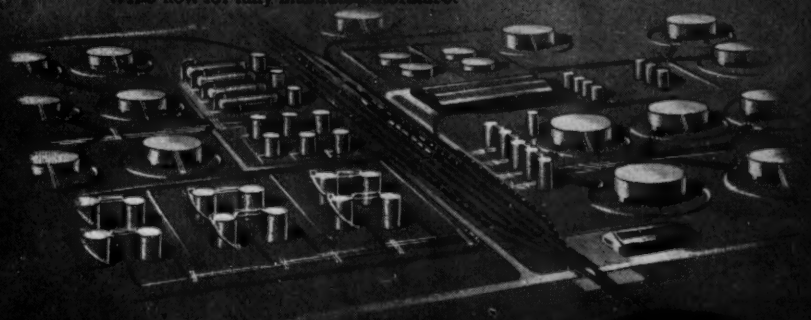

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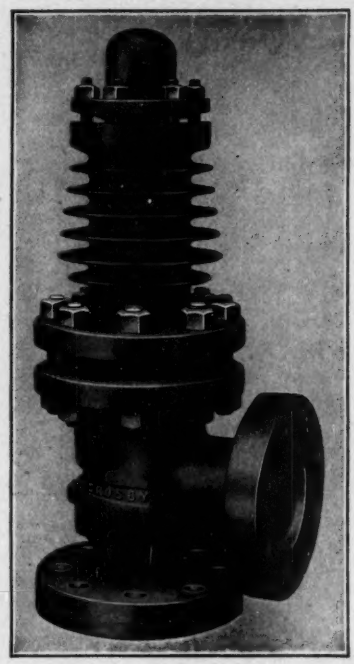

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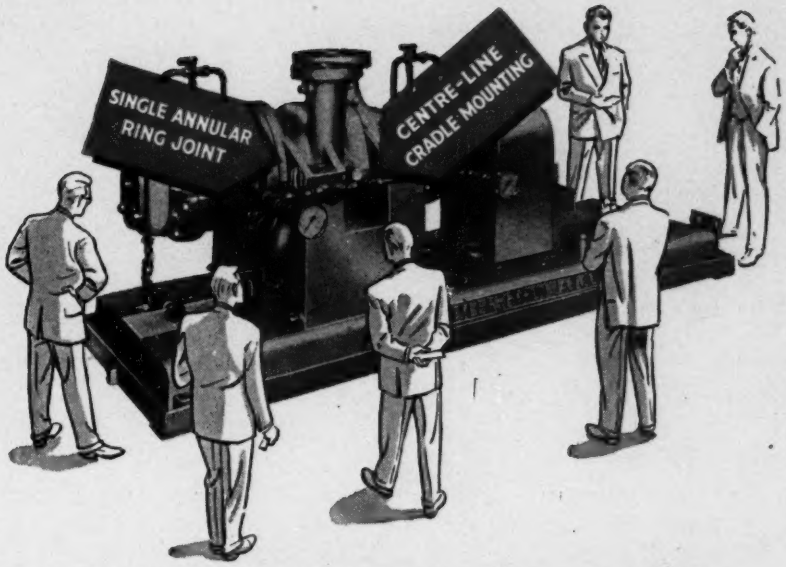

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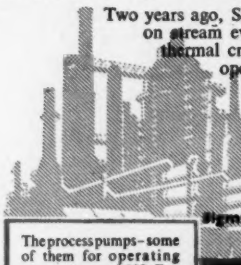

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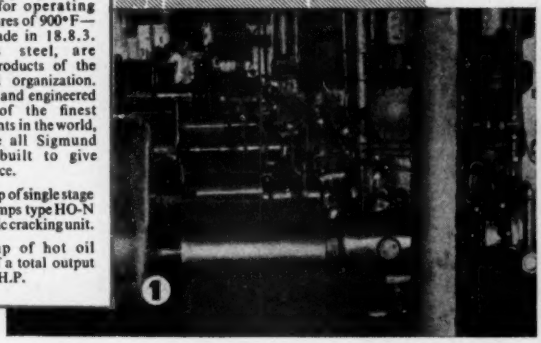

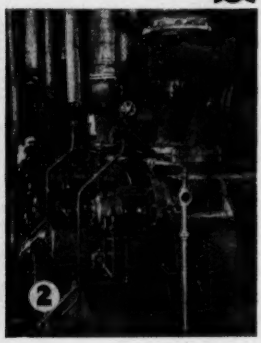

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